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PROCEEDINGS

OF

THE LINNEAN SOCIETY OF LONDON.

143RD SESSION.

FROM OCTOBER 1930 TO MAY 1931.

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PROCEEDINGS

OF

THE LINNEAN SOCIETY OF LONDON.

(ONE HUNDRED AND FORTY-THIRD SESSION, 1930–1931.)

GENERAL MEETINGS.

23rd October, 1930.

Sir Sidney F. Harmer, K.B.E., F.R.S., President, in the Chair.

The Proceedings of the Anniversary Meeting, held on Thursday, the 24th May, 1930, having been circulated, were taken as read and confirmed.

A list of names of those who had made gifts to the Library since the previous meeting was read and laid on the table.

The following Fellows signed the Obligation in the Book of the Charter and Bye-Laws and were admitted :—Basil Harrington Soulsby and Harry Howard Allan.

Certificates of recommendation of the following candidates for Fellowship were read :—For the first time, in favour of Gwendoline E. Kirby, Charles McCann, Herbert Wesley Lawton, Walter Woodward Allen, Elaine de Sainte Croix Fogg, Louis William Gordon Malcolm, Henry Rissik Marshall, and Lily Newton.

The President reported the death of our Foreign Member, Professor H. G. A. Engler ; and pointed out that it was open for any Fellow to fill in a form of recommendation for a new Foreign Member.

Issued December 17th.]

The Development of the External Features of Xenopus lævis Daud., based on material collected by the late Dr. E. J. Bles. By **Professor Karl Peter.** (Communicated by Mr. G. R. DE BEER.)

The earlier stages of the development of *Xenopus* were treated by the late Dr. E. J. Bles in his paper on "The Life-history of *Xenopus lævis*," but ill-health unfortunately prevented him from completing his observations on later stages, although a number of beautiful drawings of tadpoles were executed by Mr. Maxwell under Dr. Bles's directions. This study has now been completed by Professor Karl Peter from Dr. Bles's material, to which some of his own was added.

Xenopus is a most interesting and beautiful object of study because of the remarkable transparency of the tadpoles, which enables the internal organs to be seen through the skin. In the region of the head even the distribution of the nerves and blood-vessels, and the muscles, can be followed with ease. An interesting feature is the presence on the head of the embryo of a glandular organ whose function is to soften the egg-membrane preparatory to hatching. Dr. Bles showed by experiment that in *Xenopus* contact between this organ and the membrane was necessary for hatching to take place, and he also demonstrated the presence of a similar hatching mechanism in *Hyla*. In other animals this mechanism has been found in Opisthobranchs, *Loligo*, Ascidians, *Lepidosiren*, and Teleosts. An analogous result is produced by the "egg-tooth" of Reptiles and Birds.

The swimming tadpole, with its flattened head and a pair of streaming tentacles attached close to the mouth, shows a curious resemblance to some Siluroid fish. It has been suggested that the tentacles of *Xenopus* (the only Anuran in which they are known to occur) may represent the balancer of certain Urodele larvæ; but the view that these structures represent external gills on the mandibular arch is very improbable. Associated with the markedly aquatic mode of life of the adult, the sense-organs of the lateral-line system do not atrophy at metamorphosis, but persist as functional organs in the adult. The external gills are never more than rudimentary, and remain in the form of simple unbranched threads. The internal gills are replaced by a system of filter-processes. There are no horny teeth round the mouth of the tadpole, but a remarkable development of horny structures is to be noted in the sharp claws with which three of the toes are armed.

The importance of the systematic position of *Xenopus*, with its curious combination of primitive and specialised characters, some of which are unique in the Anura, together with the fact that it is used as a standard laboratory type in South Africa,

makes it very desirable that a series of plates (such as those which illustrate this paper) should be available to zoologists.

Mr. R. H. Burne expressed his satisfaction that the valuable material brought together by the late Dr. Bles was now in process of being worked out by Prof. Peter, and that thus the important research started by Dr. Bles would be carried to completion.

He referred to the mixture of archaic characters with recent adaptive modifications in this group of Toads, and welcomed a full investigation of their developmental history as likely to give information of the highest interest.

Professor J. T. Wilson (Visitor) said that he regarded it as a privilege to have been invited to be present and to offer a few remarks on this occasion. For this, his only warrant lay in the fact that the material on which the research now under notice had been carried out represented a portion of the very considerable amount of embryological material, books and apparatus handed over to the Embryological Laboratory of the Cambridge Anatomy School by the Trustees of the late Dr. Bles. The highly interesting collection of *Xenopus* developmental material was held, pending its effective utilization by a specialist in amphibian development. It was fortunate that the work was at length undertaken by so competent and distinguished an authority as Professor Karl Peter, and it was most gratifying to them in Cambridge to realize that this work, in prolongation of the long-continued and devoted research of Dr. Bles into the anatomy and biology of *Xenopus*, is to obtain early and adequate publication through the Linnean Society. It must also be regarded as most fitting that the extension of Dr. Bles's investigation should have fallen to the hands of one who was not only so specially well qualified as Professor Peter, but of one who had himself been for long in intimate and friendly scientific association with Dr. Bles.

Major Stanley S. Flower asked for information concerning the voice and the use of the sharp claws on the hind-feet of *Xenopus*. Dr. Edward Hindle had given him a pair of live *Xenopus lævis* on May 6, 1930. He had observed that the claws on the hind-feet are used to tear meat to pieces : when the frog has seized a piece of meat too large to swallow, it holds the meat in its jaws, with both hands helping to steady it, and then brings forward a hind-foot, and slashes at the meat till pieces are torn off that can be swallowed. He had not been able to find out whether only the male or only the female, or both sexes, were vocal. Two calls come from their tank, one a " rattling " or " tapping " sound, like a machine-gun in the far distance *, the other a " piping " or thin " whistling " noise.

* *Cf.* J. M. Leslie, P. Z. S. 1890, p. 71 : " a peculiar dull *tick-tick* note."

Professor E. W. MacBride said that he had listened with deep interest to the paper by Dr. Peter so ably presented by Mr. de Beer. He rejoiced that these beautiful drawings, which Dr. Bles had caused to be executed and which represented his final work, were to be published, and he earnestly hoped that the colours, so vividly recalling the appearance of the living tadpoles, would be reproduced. His friendship with Dr. Bles dated back to 1893, when Dr. Bles was Director of the Plymouth Biological Station. After he had resigned that post Dr. Bles came to Cambridge as a research student, and in his room Prof. MacBride first saw the living larvæ of Newts and living specimens of the gilled Cave-Newt *Proteus anguineus*, and still possesses a photograph of one of these extraordinary creatures shown to him on that occasion. Dr. Bles's predominating interest in zoology had always been the development of Amphibia, and his earlier papers on the subject could only be described as classical. Every year, when in his course of lectures Prof. MacBride approached the subject of embryology, he found it necessary to refer to these papers in order to refresh his memory. In the course of his investigations on the development of the kidney of the Anura Dr. Bles made the surprising discovery that the ciliated funnels on the surface of the kidney did not lead into the kidney tubules, as was the case with the corresponding funnels of the Urodela, but communicated with the blood-vessels. Prof. MacBride well remembered how, when Dr. Bles presented this discovery at a meeting of the Cambridge Philosophical Society, he himself, in the rashness of youth, questioned its accuracy. In recent years Prof. MacBride had had the development of the Anuran kidney re-examined in his own laboratory, and all Dr. Bles's statements had been found to be correct. *Xenopus*, the subject of the paper to which they had just listened, was a most interesting form ; it was an instance of an animal descended from ancestors adapted to a predominantly land life readapted to an existence in water.

The development of the vertebral column of *Xenopus* had been studied in the Zoological Department of the Imperial College. Whereas in other Anura the centra were formed as rings of cartilage surrounding the notochord, and traces of the notochord could still be discovered inside the bony centra of the fully-developed frogs and toads, in *Xenopus* the centra were formed as little curved strips of cartilage from the dorsal portions of the notochordal sheath, and the whole of the notochord, including the rest of the sheath, disappeared at metamorphosis. This formation of the centra as flat strips was in harmony with the general flattening of the body, which had earned for *Xenopus* the name "Platt Anna" among the Dutch inhabitants of S. Africa.

Prof. MacBride rejoiced to think that in Dr. Peters's forthcoming work not only the changes in external appearance, but also the growth of the internal organs, would be subjected to a thorough investigation.

Miss E. Trewavas (Visitor) remarked that, with reference to Major Flower's remarks on the voice of *Xenopus*, it is interesting to recall that Dr. Ridewood showed that the larynx of this and related genera differs from that of other Anura, and is more massive and specialised in the male than in the female.

The President referred to his personal recollections of Dr. E. J. Bles, who was a member of his own College at Cambridge. Dr. Bles was a most careful worker, who spared no pains to make his results reliable. For a short period he had occupied the office of Director of the Marine Biological Association at Plymouth; and by his Will he bequeathed a munificent benefaction to the University of Cambridge for the encouragement of biological research. The possibility of publishing the drawings of *Xenopus* in a style worthy of the beauty of their execution has been due to the generosity of Mrs. Bles.

On a Scolecopteris (S. Oliveri sp. nov.) from the Permo-Carboniferous of Autun. By **Dr. D. H. Scott, F.R.S.**

The specimen, of which nine sections were prepared by Mr. W. Hemingway, consists chiefly of numerous leaflets, fertile and sterile, with portions of other organs. The fertile leaflets bear the reproductive organs, the synangia, on their lower surface. The number of sporangia in each synangium is usually four, but five also occur. The synangium is seated on a pedicel; the plant is therefore a true *Scolecopteris*, differing from *Acitheca*, in which the constituent sporangia are grouped around the pedicel, and from *Asterotheca*, in which the synangia are borne directly on the frond, without any pedicel. The amount of cohesion between the sporangia is very slight, but enough to justify the term "synangium." The spores are small, about 18 μ in diameter. The fructification is closely similar to that of *S. elegans* Zenker and *S. minor* Hoskins, but the dimensions of the synangia are greater than in either of those species, and there are some differences in details of structure. The plant is therefore treated as a new species, *Scolecopteris Oliveri*, named after Prof. F. W. Oliver, who brought the material from Autun nearly thirty years ago.

The preservation is in most respects very good. The sterile leaflets show very clear stomata, as first detected by Prof. H. S. Holden, to whom the author is indebted for much help. The characters of *Scolecopteris* appear to indicate Marattiaceous affinities, as usually held, rather than a position among the Pteridosperms, as suggested by the late Dr. Kidston.

Mr. W. N. Edwards and Dr. Margaret J. Benson commented on the paper.

On the Cuticles of some Recent and Fossil Myrtaceæ. By Dr. Helena Bandulska.

The investigation demonstrates the presence of one species of *Rhodomyrtus* in the Bournemouth Eocene and of one species of *Tristania*. One species of *Tristania* is also described from the Pliocene of Tuscany. The cuticular structure of the three species is dealt with.

Rhodomyrtus.—The leaves of this genus are simple, entire, variable in length, and more or less tomentose. The venation is pinnate or may appear tri-nerved, and is frequently obscure on the upper surface, especially after drying. The cuticles in all the species examined have lower epidermal cells with sinuate walls. Hairs and hair-bases are present, the latter like thickly cutinised collars with radiating spikes of cutin. In the Bournemouth specimen the stomata are not much below the surface. They are variable in size and elliptical, bearing scales which arch over the pore. The guard-cells have thin outer walls, and their junctions show a T-shaped cutinisation at the poles of their long axes. Their inner rims show a wide deeply-staining border, and have a cutinised edge. Narrow paired subsidiary cells may occur parallel to the guard-cells, but are not always visible in surface view.

Tristania.—The leaves of this genus are simple, alternate, petiolate or sessile, coriaceous, glabrous, lanceolate to ovate or obovate. The margin frequently has an occasional notch. The veins are numerous or few and often obscure.

The stomata are very numerous and only slightly below the surface, but they are efficiently protected by unicellular hairs, cuticular hooks, or scales. The guard-cell junctions are delicate and have sometimes a slight dagger-shaped cutinisation. The guard-cells themselves are oblong or isodiametric, and slightly variable in size. Isolated "giant" stomata are occasionally seen. Girdling epidermal cells varying in shape, size, and number, but more distinctive and numerous than in *Rhodomyrtus*, surround the stomata. The epidermal cells vary much in amount in the different species, and may have straight or sinuate walls.

There is a strong family resemblance between the cuticles of *Rhodomyrtus* and *Tristania*. They differ from each other in the greater tendency of the stomata to be isodiametric in *Tristania*, and also in the larger number of narrow and very distinctive girdling cells encircling the guard-cells in *Tristania*. There is less parenchyma and there are more stomata per unit of area in *Tristania* species than in *Rhodomyrtus* species.

Mr. W. N. Edwards, in introducing Dr. Bandulska's paper,

quoted a suggestion made as long ago as 1858 by Sir Charles Bunbury, that "the cellular structure of the epidermis [of fossil plants] and its pores or stomata . . may probably afford valuable aid towards the determination of affinities." As an example, Bunbury had pointed out the distinctive character of the epidermis of *Ginkgo*, and stated that it was "exceptional in the family of Coniferæ."

The presence, as shown by cuticular study, of *Tristania* and *Rhodomyrtus* in English Eocene beds was of interest because at the present day these genera lived in the Sino-Malayan region, the flora of which, as shown by recent research, had a close affinity with the early Tertiary floras of Europe.

Dr. D. H. Scott congratulated the author on the continuation of her valuable work, and expressed regret at the report of her illness. He thought it of great importance that Mrs. E. M. Reid had confirmed by independent evidence the occurrence of the genus *Rhodomyrtus* in the Eocene of Europe, as inferred by Dr. Bandulska from the cuticular structure.

Dr. A. B. Rendle remarked on the importance of Dr. Bandulska's work in supplying definite structural characters in addition to superficial characters drawn from leaf-impressions, and commented on the skilful technique indicated in the author's preparations and on the extensive examination of recent specimens which formed the basis of her determinations. In view of the increasing difficulties in obtaining specimens from the Bournemouth beds, it was important that accurate records of the species should be obtained.

Mr. I. H. Burkill spoke regarding the present dispersal of genera found in the Eocene of Britain. Giving the most western localities for living *Rhodomyrtus* and *Tristania* as the hills of Assam south of the Brahmaputra and of Burma whence they extend through Malaysia, he suggested that the climate of Eocene Britain might as easily be that of the Indo-Chinese region as of Malaya, the difference being that the Indo-Chinese region has marked alternating seasons, whereas Malaya scarcely possesses them. Until leaves of genera, such as *Durio*, with their present distribution only in Malaysia be found, it is safest to assume the climate of Eocene Britain, as that of Indo-China and the Eocene plants of Britain, to have been more or less tropophytic. Why this Eocene flora found no refuge in Africa when destroyed in Europe but persisted in Eastern Asia presents a very interesting problem.

The Botanical Secretary stated that he regretted to inform the meeting that it was unlikely that Dr. Bandulska would be able to continue her researches. He asked that he might be authorised to express to her the sympathy of the Fellows while thanking her for her valuable paper.

6TH NOVEMBER, 1930.

Sir SIDNEY F. HARMER, K.B.E., F.R.S., President, in the Chair.

The Proceedings of the previous Meeting, held on Thursday, the 23rd October, 1930, having been circulated, were taken as read and confirmed.

A list of names of those who had made gifts to the Library since the previous meeting was read and laid on the table.

The following Fellows signed the Obligation in the Book of the Charter and Bye-Laws and were admitted :—Robert Burgess and Ivor Vicary Newman.

Certificates of recommendation of the following candidates for Fellowship were read :—For the second time, in favour of Gwendoline E. Kirby, Charles McCann, Herbert Wesley Lawton, Walter Woodward Allen, Elaine de Sainte Croix Fogg, Louis William Gordon Malcolm, Henry Rissik Marshall, and Lily Newton. For the first time in favour of Marian Whelan and Henry Arthur Potter.

On a new species of the genus Hoplophorus [Oplophorus] H. M.-Edw. By [the late] **Dr. J. G. de Man.** (Communicated by Dr. G. P. BIDDER.)

Dr. W. T. CALMAN gave an account of this paper, which describes a new species of deep-sea prawn belonging to the genus *Hoplophorus*. The specimens were taken f om the stomach of a groper, *Polyprion prognathus*, captured in two fathoms of water off the east coast of the South Island of New Zealand, at a place where deep water comes to within a short distance of the shore. The specimens were sufficiently complete to allow of a very detailed description and comparison with the four species of the genus already known. Dr. Calman made some remarks on the spelling of the generic name.

Referring to Dr. Calman's remarks on the Greek aspirate, the PRESIDENT alluded to similar inconsistencies fr quent in zoological nomenclature, as in the case of the genera *Halcyon*, *Alcyonium*, and *Alcyonidium*.

Brachyura from the coasts of China. By **Dr. Isabella Gordon.** (Communicated by Dr. W. T. CALMAN, F.R.S.)

This paper describes the material contained in several collections of Crustacea, chiefly Brachyura, from Hong Kong and other localities on the Chinese coast. Among the rarer species represented are (1) a species of *Ixoides*, probably *I. cornutus* MacGilchrist, but all the specimens are damaged ; (2) *Lyreidus politus* Parisi ; (3) *Lissocarcinus arkati* Kemp ;

(4) *Macrophthalmus teschi* Kemp; (5) *Paracleistostoma depressum* de Man, and three species of *Porcellana* (*P. ornata* Stimpson, *P. pulchra* Stimpson, and *P. spinulifrons* Miers).

The following species have been described as new (see Ann. & Mag. N. H., ser. 10, vol. vi, no. 34, 1930, pp. 519–525):—*Pugettia cristata*; *Charybdis* (*Goniosoma*) *barneyi*; *Charybdis* (*Goniohellenus*) *sinensis*; *Pilumnus penicillatus*: *Pilumnus sinensis*; *Litocheira amoyensis*; and *Metaplex sheni*. New names have been given to two forms—*Pugettia sagamiensis* (*P. brevirostris* Parisi *nec* Doflein) and *Neptunus* (*Hellenus*) *pulchricristatus* (*N. spinipes* Alcock *nec* Miers). The last-named species was described as *N. alcocki* in the preliminary report referred to above, but the name is preoccupied.

In the endeavour to find satisfactory systematic characters for the discrimination of closely related forms, particularly in the families Xanthidæ and Portunidæ, attention has been given to the form of the abdominal appendages in the male sex. These appendages have not hitherto been much utilised for systematic purposes in these families, but they appear to afford a ready and reliable means of distinguishing males of many of the species discussed in this paper; and a less detailed survey of other species suggests that they will afford useful characters for those also. With regard to the genus *Pilumnus*, among the Xanthidæ, most of the species examined had rather similar male appendages that were easily separable into two groups; it is of interest to record that the same two types were found also in the genus *Litocheira* among the Gonoplacidæ, a family containing forms with many Xanthid affinities.

Dr. W. T. Calman made some congratulatory remarks on the author's work.

Mr. J. T. Cunningham asked if there was any evidence that the expanded posterior legs of the common British swimming-crabs were used also for burrowing, as Dr. Gordon had stated to be the case in certain swimming-crabs of China.

Mr. A. G. Lowndes called attention to the fact that some feature of a particular appendage in other groups of Crustacea might or might not be of the greatest specific importance. In a great number of the species of *Cyclops* (sens. lat.) there is a hyaline membrane on the last joint of the first antenna which shows certain modifications. Breeding experiments have shown that these modifications may or may not be of value to the systematist. Thus in the genus *Leptocyclops* they are of the greatest value, while in *Mesocyclops* they are of no value.

The President congratulated Dr. Gordon on the value of her paper and on her attempt, which appeared to be successful, to find new characters useful in the discrimination of species.

Dr. Gordon briefly replied.

Some Remarks on Hybridism in the New Zealand Flora.

By Dr. H. H. Allan.

It has been customary to consider the New Zealand flora as rather "well known," but to contain a great percentage of very "variable" species. All the existing Floras reflect the opinions and methods, admirable and necessary in their day, of that great taxonomist J. D. Hooker, who held very wide views as to the content of species. Thus the numerous forms of *Rubus* known to him from New Zealand were all placed under the one species, *R. australis*. Although later systematists have recognized several species, these have been mainly very ill defined, and considered to "run into" one another. So, too, the name *Olearia arborescens* has been used to apply to a huge group of forms "varying" from a tiny-leaved, densely divaricating, low shrub to a large-leaved canopy tree. To the ecologist such vaguely limited names were of very little service.

The past decade of botanical research in New Zealand shows as its outstanding feature the discovery of the prevalence of wild hybridism, and the recognition that these hybrids, in the majority of cases, are not merely occasional "intermediates," but form extremely polymorphic swarms showing a high degree of fertility. Well over 400 such groups have now been definitely ascertained, distributed among about 95 genera and 45 families. They occur often between species of the most diverse character. The mat-forming semi-woody plant *Helichrysum bellidioides*, e. g., hybridizes with the shrub *H. glomeratum*, some of the hybrids being lianoid. The overwhelming field-evidence for these conclusions has been sufficiently reviewed in recent publications by Cockayne and the writer.

A re-examination of the flora in the light of hybridism has more and more revealed that the so-called "variability" of the species is to be attributed to this cause, and that in the absence of opportunity to hybridize no variation occurs, but distinct true-breeding units can usually be readily recognized. Apart from unstable environmentally-induced forms—the epharmones, as Cockayne and I have called them—and the occurrence of some 200 heteroblastic species possessing a juvenile form very different from that of the adult, there is no evidence of inheritable variability *per se*. It is hardly too much to say that a revolution has taken place in the taxonomic methods of New Zealand botanists. The vaguely limited groups, composed of a mixture of true-breeding elements, with their hybrids and epharmones—linneons, as Cockayne and I use that term—are being subjected to analysis. Or, rather, the

method is one of synthesis, the true-breeding forms being first sought out and differentiated from the hybrid populations they may produce, and then grouped according to relationships. The term jordanon, as defined by Lotsy, so well fits these elements that Cockayne and I have adopted it. The jordanons can as a rule be recognized from field evidence as to constancy of form and offspring, coupled with cultural and breeding tests in the more difficult cases. We recognize that Lotsy himself intended his term to apply to still smaller units—the microspecies—the recognition of which requires more intense genetic research than is necessary for general ecological and taxonomic purposes. Until this test of constancy of form had been applied, no botanist had recognized that there existed a jordanon of *Fuchsia* in New Zealand characterized, among other things, by its being a true liane. This *Fuchsia perscandens*, however, in places meets and hybridizes with the trec *F. excorticata*, producing shrubby and semi-lianoid plants that in part have gone under the name *F. Colensoi*. On Mount Marchant, Tararua Mountains, occurs a polymorphic population of *Coprosma*, no one plant quite matching another. By comparison with series collected in other localities it has been possible to analyse this swarm as being the result of the crossing of three distinct species—*C. Colensoi* (the *C. Banksii* of New Zealand botanists), *C. fœtidissima*, and a third species (the *C. Colensoi* of New Zealand botanists in part). The extremely complex group going under the name *Leptospermum scoparium* has not yet received serious attention, and it is evident that close genetic studies must be made before its taxonomy can be satisfactorily determined.

Where a jordanon has no opportunity of hybridizing it remains perfectly true to its characters, the offspring faithfully repeating the parental form. In some cases no opportunity occurs at all, and we have the few " invariable " species of the flora. The genera, e. g., *Agathis*, *Corynocarpus*, *Dysoxylum*, *Entelea*, *Ixerba*, *Phebalium*, are represented by one species each, and these species are perfectly uniform throughout their range. Other species may be geographically or ecologically isolated for the most part, but have an opportunity of crossing in one or a few localities, and it is in these localities that the otherwise constant species become " variable," e. g., *Corokia buddleoides* and *C. Cotoneaster*, *Melicope simplex* and *M. ternata*, *Ranunculus Buchanani* and *R. Lyallii*. From such cases to those where very frequent opportunities of crossing occur there are all grades of conditions.

Certain jordanons are so isolated taxonomically from all others that they may be termed *simple species*, e. g., *Hebe Astoni*, *H. cupressoides*. Others fall into closely related

groups and may be spoken of as varieties of a *compound species*. Thus the linneon *Hebe salicifolia* has been found to be made up of a number of jordanons, several of which meet and hybridize, together with hybrids between jordanons and other species. Of the compound species itself the varieties *Atkinsonii*, *egmontiana*, *longeracemosa*, and *paludosa* have been definitely recognized. As used by Cockayne and myself the term *variety* is always intended to refer to a true-breeding unit of a compound species.

It is equally important to study and determine environmental forms and to distinguish these from strictly taxonomic units. *Ranunculus Monroi* exhibits a number of habitat forms, the extremes so distinct and occupying such different ecological niches that without cultural experiments they might easily be mistaken for jordanons with hybrid intermediates. Epharmony may be exhibited in part of an individual as well as in whole plants, and this must be borne in mind in collecting and examining specimens. Pieces gathered from the crown and from the lower branches of species of *Nothofagus*, for instance, may show features of considerable distinctness, though there is no abrupt heteroblasty.

Certain heteroblastic species may flower in the juvenile or semi-juvenile state, and imperfectly annotated herbarium specimens may easily be misinterpreted as distinct species. A striking case is that of *Pennantia corymbosa*, where the three diverse stages (juvenile, semi-juvenile, adult) may be found in flower on different plants or on the same individual and where the inflorescential and floral characters show certain differences at the different stages.

I have not time to enter into the wider aspects of the question, but it is evident that a much more intensive examination of species said to be common to more or less distant regions must be made on the jordanon basis before much further progress can be made with problems of geographical distribution and the wider problems of evolution that such studies open up. *Oxalis magellanica* of South America, *O. lactea* of Tasmania, and *O. cataractæ* of New Zealand were considered by Hooker to be one and the same species, with a remarkable distribution. Skottsberg decided that *O. magellanica* presents marked differences from *O. lactea*. On an examination of the material available at the herbaria at the Royal Botanic Gardens, Kew, and at the British Museum of Natural History, coupled with my field knowledge of the New Zealand species, I unhesitatingly agree with Skottsberg that *O. magellanica* is quite distinct from *O. lactea*. I find, too, that *O. cataractæ* is identical with *O. lactea*. But the important point that emerged was that *both O. lactea* and *O. magellanica* occur in South America, while only *O. lactea* is found in New Zealand. The genus *Coriaria* provides an excellent

opportunity for work of the kind I am advocating. The material at present available is far too imperfect for any satisfactory conclusions to be drawn as to the relationships of New Zealand and of South American forms. I have commenced a detailed examination of the genus in New Zealand, so that adequate material and information may be acquired for thoroughgoing comparison.

To sum up, the conclusions to which the study of the wild hybrids of New Zealand has led are: (1) that the species is a reality, and, on the jordanon basis, most can be quite definitely defined; (2) that in very many cases field evidence is of itself conclusive as to the status of different forms; (3) that "variability," apart from epharmony and heteroblasty (which itself may be connected with hybridism), is due to hybridization; (4) that progress in studies of geographical distribution waits on an exact comparison of the true-breeding units of the areas concerned.

Mr. G. W. E. Loder, in thanking Dr. Allan for his paper, thought that the investigations and experiments which he had undertaken on the question of variation and hybrids in the flora of New Zealand were of the highest importance. The flora was one of the most interesting in the world, and was deserving of the increasing interest it was attracting. They would look forward to hearing the results of his work, and hoped that on some future occasion he would communicate them to the Society. Mr. Loder took the opportunity of paying a tribute to the long and valuable services of Dr. Cockayne to botanical science in New Zealand.

Dr. O. Stapf joined Mr. Loder in his appreciation of the work of Dr. Cockayne and his school, of which Dr. Allan is a worthy representative. It is in line with the most modern achievements of botanical research, and it is to be wished that it be taken as a model for similar investigations in other Dominions. If it upsets not a few of the conceptions of the earlier writers on the flora of New Zealand, it need not lower our valuation of their work, which was pioneer work and in part dates back very far indeed, but is, with all its shortcomings, still the basis, without which the progress we welcome to-day would have been impossible.

Prof. E. J. Salisbury, who emphasised the interest of Dr. Allan's communication, asked if there was any evidence as to whether the members of the hybrid swarms ever spread into communities or habitats differing either synecologically or edaphically from those occupied by either of the parent hybridizing species. This was a question of great ecological importance, and one which Dr. Allan had exceptional opportunities of studying.

Mr. W. D. Francis and Lt.-Col. J. H. Tull Walsh also commented on the paper.

20th November, 1930.

Sir Sidney F. Harmer, K.B.E., F.R.S., President, in the Chair.

The Proceedings of the previous Meeting, held on Thursday, the 6th November, 1930, having been circulated, were taken as read and confirmed.

A list of names of those who had made gifts to the Library since the previous meeting was read and laid on the table.

Certificates of recommendation of the following candidates for Fellowship were read :—For the second time in favour of Marian Whelan and Henry Arthur Potter. For the first time in favour of Prabhat Chandra Sarbadhikari and Mandayam Osuri Parthasarathy Iyengar.

Lt.-Col. J. Stephenson gave an account, illustrated with lantern-slides, of **Mr. R. Gopala Aiyar's** paper, "**An account of the development and breeding-habits of a brackish-water Polychæt worm of the genus** *Marphysa*." (Communicated by Dr. E. S. Russell.)

A species of *Marphysa* lives in the mouth of the Adyar River (Madras) and the neighbouring backwater. The mouth of the Adyar is usually closed and the water brackish ; at the beginning of the rains the swollen river establishes a connection with the sea. The spawn of the worm is found mainly from February to September as pear-shaped jelly-like masses in which the tiny black eggs are embedded. These masses are usually attached to the bottom by their stalks, which are strengthened by an incrustation of the fæces of the worm ; some masses, however, float freely. A number of worms appear to live in the soil near the margin of the river as its level falls in the dry season ; when the river swells so as to cover this belt at the first heavy rain these lay their egg-masses in quantities. A marshy plain lying on the north side of the Adyar may, when flooded by the river after rain, show numerous spawn masses, often amongst the aerial roots of *Avicennia* shrubs. Higher up the river, where the water is fresh, no spawn masses are laid.

The development of the eggs was observed in the laboratory over a period of eight months ; it was necessary to obtain the water of the Adyar almost daily, as sea-water was fatal to the larvæ. The spherical eggs become uniformly ciliated, and revolve in the jelly. The prototrochophore stage is transient ; there is no trochophore stage, nor any free-swimming stage at

all. The initial metatrochophore (with eyes, apical tuft of cilia, and two ciliary bands, one very broad and one narrow) and late metatrochophore (with two setal bundles) are passed through in the jelly. In the nectochæta stage the cilia are lost, the jelly disintegrates, and the larvæ sink to the bottom and begin a creeping existence. Lastly, the creeping life is given up as new segments are added, and the tiny worms construct small tubes formed mainly of organic débris cemented together by mucus. The length of development is nearly six months.

Col. Stephenson, in commenting on the paper, acknowledged its great interest, but he regretted that the author had omitted such details as the size of the spawn masses, the mode of oviposition, and salinity determinations of the water. The apparently almost terrestrial habit of some of these worms was noteworthy, and also the adaptations to *non*-dispersal —the development within masses of jelly attached to the bottom, the loss of the trochophore stage, and the absence of any free-swimming stage in the life-history. While the continued existence of most species depends on the possession of means of spreading, here spreading out to sea apparently means destruction. The name nectochæta properly denoted a free-swimming larva, and should not be transferred to a creeping stage.

Mr. C. C. A. Monro congratulated Col. Stephenson on his presentation of Mr. Gopala Aiyar's paper. He said that pyriform gelatinous egg-masses, similar to that described by Mr. Aiyar, were common objects in brackish-water lagoons on the east coast of India and on the Malay Peninsula, and that these were generally regarded as belonging to *Marphysa gravelyi* Southern, which has also been recorded from Krusadai Island in the Gulf of Manaar. In his opinion the form described by Mr. Aiyar was probably identical with *Marphysa gravelyi*, especially as Mr. Aiyar states that the adult has only capillary bristles in the posterior neuropodia, a feature which is characteristic of *Marphysa gravelyi*. Borradaile has described a very similar development of a *Marphysa* from the north coast of Ceylon; Mr. Monro held that Borradaile's larvæ also probably belonged to *Marphysa gravelyi*. Mr. Aiyar's suggestion that the loss of the free-swimming larval stage in development was an adaptation to special brackish-water conditions, in which it was an advantage to avoid dispersal, was ingenious, but it should be borne in mind that *Marphysa gravelyi* has a wide local range, that another brackish-water Polychæte, *Mercierella*, can establish itself in a new brackish-water habitat after having been carried great distances through the sea, and that the

free-swimming stage of development is lost in a number of Polychætes, for which, as far as is known, there is no advantage in the avoidance of dispersal.

The PRESIDENT, having expressed the thanks of the Meeting to the author and to Col. Stephenson, commented on the difficulty of accounting for the dispersal of brackish-water animals. It appeared to him that the inclusion in a mass of jelly of the eggs of the *Marphysa* described is not necessarily an adaptation to brackish-water conditions, in view of the fact that Polychæte eggs similarly enclosed are common between tide-marks on British beaches.

Mr. R. E. Holttum gave a paper, illustrated with numerous lantern-slides, on **Malayan Ferns, and a few from Java, growing under natural conditions.** The arrangement was ecological, and the illustrations exhibited so far as possible the range of plant-form and of habitat found within the group.

Sun-ferns.—In forest clearings and open spaces are found a number of ferns tolerant of sunlight and free exposure to the air. Of these, species of *Gleichenia* are probably the most abundant. In the lowlands *G. linearis* (Burm.) Cl. (in several varieties) and *G. lævigata* (Willd.) Hk. are the commonest; at about 2500 feet and higher altitudes *G. glauca* (Thb.) Hk. is often found in large masses; *G. circinnata* Sw. (or *G. vulcanica* Bl.) occurs on mountain tops in poor sandy soil, often in association with *Sphagnum* spp. Bracken occurs at all elevations from sea-level upwards, both the southern form *Pteridium esculentum* (Forst.) Nakai (which apparently does not extend far on the mainland of Asia) and a form very like the northern *P. aquilinum*, though often very hairy. *Dipteris conjugata* Reinw. is a sun-fern of clearings and landslide areas in the mountains, sometimes occurring at lower altitudes, and in Singapore actually on the sea-coast. *Matonia pectinata* R. Br. is a sun-fern of mountain tops, in poor sandy soil, often associated with *Sphagnum*. Other mountain sun-ferns illustrated are *Oleandra colubrina* (Blanco) Copel., *Lindsaya rigida* J. Sm., and *Dryopteris viscosa* (J. Sm.) O. Ktze. The species of *Lygodium* (except *L. polystachyum* Wall.) and *Stenochlæna palustris* (Burm.) Bedd. are climbing sun-ferns of the lowlands.

Terrestrial Shade-ferns.—The terrestrial fern flora of ordinary lowland forest and on lower mountain slopes, except in the neighbourhood of streams, is not very rich. Species vary considerably in their demands for water and shade. Examples of this group illustrated were *Aspidium subdecurrens* (Luersss.) C. Chr. (a broad-leaved lowland fern), *Lindsaya tenera* Dry. (occurring from about 1000 feet upwards), *Angiopteris* sp.,

Cyathea brunonis (Wall.) Pr. and *Cyathea alternans* (Wall.) Pr. (short-stemmed tree-ferns with relatively simple leaves). The larger tree-ferns (*Alsophila* and *Cyathea* spp.) are usually characteristic of more open places in the forest, though they are not often found in the full sun, except *A. glauca* (Bl.) J. Sm., the largest and commonest mountain species. A few ferns are characteristic of the ridge forest of high mountains; among these *Plagiogyria tuberculata* Copel. and *Blechnum vestitum* (Bl.) Kuhn were illustrated. *Polypodium Feei* (Bory) Mett., also illustrated, is found in Java in the dwarfed forest on the upper slopes of volcanoes, growing sometimes beyond the forest almost to the crater's edge, in thick masses, where no other vascular plants exist.

Stream-side and Rock-Ferns.—Near streams the terrestrial fern flora is always richer than elsewhere in the forest; there are also certain species of ferns which are characteristic of the banks of streams and grow nowhere else. Species found by streams which are subject to sudden flooding are *Dipteris Lobbiana* (Hk.) Moore and *Dryopteris salicifolia* (Wall.) C. Chr., both with tough narrow leaflets though quite different leaf-form. Other ferns are found by smaller streams, or where heavy flooding is not normal: examples shown were three species of *Trichomanes*, *T. maximum* Bl., *T. javanicum* Bl., and an unidentified species; also *Leptochilus decurrens* Bl. Some stream-bank ferns grow only on rocks; common examples are *Leptochilus diversifolius* (Bl.) C. Chr. (of which both a mature plant and sporelings on a rock surface were illustrated) and *Polybotrya appendiculata* (Willd.) J. Sm. The interesting small limestone fern *Lastrea chupengensis* Ridley was also illustrated.

Epiphytes and Climbing Ferns.—This is a very large class, and might be variously subdivided. Some ferns are characteristic of trees or rocks in open sunny places; of these *Cyclophorus* spp., *Drymoglossum piloselloides* Pr., *Polypodium phymatodes* L., and *Platycerium coronarium* (König) Desv. were shown. The very interesting *P. Ridleyi* Christ, apparently a rather rare species of the Malay Peninsula and Borneo, was also illustrated, and *P. grande* (A. Cunn.) J. Sm. and *P. Wilheminæ reginæ* v. A. v. R. (photographed at Buitenzorg). Of forest epiphytes *Asplenium nidus* L., *A. laserpitiifolium* Lam., *Davallia divaricata* Bl., *Nephrolepis acuminata* (Houtt.) Kuhn, *Polypodium heracleum* Kze., *P. coronans* Wall., and *P. tæniatum* Sw. were shown, with illustrations of mountain forest, including the curious mossy forest of high mountains. *Lecanopteris carnosa* (Reinw.) Bl., with ant-inhabited rhizome, is very abundant on the crowns of trees in mountain forest, sometimes covering nearly all the branches of a tree with the

black horny mass of its dead rhizome. *Stenochlæna gracilis* (Bl.) Kze. was illustrated as an example of a climbing fern; both the much divided "water leaves" of the young plant, clinging closely to a tree-trunk, and the larger simply pinnate leaves of the mature plant were shown. This is a very common species in mountain forests, while *S. aculeata* (Bl.) Kze. is common in the lowlands.

Mr. H. N. Ridley, after calling attention to the beauty of the photographs, pointed out that *Gleichenia* took the place of *Pteris* in the clayey soils, but *Pteris* came where there was a certain amount of sand. He called attention to the difference between the xerophytic ferns of the higher mountains and the hygrophytic ones of the lower woods, and pointed out that in Christmas Island the latter were strictly confined to the neighbourhood of the freshwater springs, the greater part of the island being of coral-rock and xerophytic. He alluded to a probable xerophytic period in the Malay Peninsula later swamped by the Eocene forest flora, and pointed out that all that remained of the plants of this period were confined to the high mountains and sea-shores, instancing *Dipteris* as one of the ferns now duly persisting in these two localities.

Mr. I. H. Burkill, having complimented the reader of the paper upon the excellence of his photographs, remarked that he would have been ready to question the xerophytic period in the history of Malaysia suggested by Mr. Ridley, and pointed to the way in which ferns draw a means of living out of a most unpromising substratum. Further, he called attention to the fact that while able to occupy a considerable variety of surfaces, they have never been able to invade the water as the Phanerogams have done—both the fresh water and the sea.

Mr. A. J. Wilmott suggested that the narrow foliage of stream-side plants might be dependent on transpiration needs, and not an adaptation connected with flooding. *Salix alba* in this country has the same form.

Dr. H. H. Allan said that the photographs had given him the impression of being back in New Zealand, so similar did the ferns of the Malayan montane forests appear to the New Zealand subtropical forest.

The President concurred with other speakers in his admiration of Mr. Holttum's beautiful photographs, which had been taken so successfully as to produce almost a stereoscopic effect.

Mr. Holttum having briefly replied, a vote of thanks to him concluded the Meeting.

4th December, 1930.

Sir Sidney F. Harmer, K.B.E., F.R.S., President, in the Chair.

The Proceedings of the previous Meeting, held on Thursday, the 20th November, 1930, having been circulated, were taken as read and confirmed.

A list of names of those who had made gifts to the Library since the previous Meeting was read and laid on the table.

Certificates of recommendation of the following candidates for Fellowship were read : —For the second time, in favour of Prabhat Chandra Sarbadhikari and Mandayam Osuri Parthasarathy Iyengar. For the first time, in favour of Isabella Gordon, Arthur Erskine Ellis, and John Joseph Sheldon.

The following candidates were balloted for and elected Fellows :—Charles Horton Bestow, Gwendoline E. Kirby, Charles McCann, Herbert Wesley Lawton, B.A., Walter Woodward Allen, B.Sc., Elaine de Sainte Croix Fogg, B.Sc., Louis William Gordon Malcolm, M.Sc., Henry Rissik Marshall, B.A., Lily Newton, M.Sc., Ph.D., Marian Whelan, B.Sc., and Henry Arthur Potter.

Grevillea Gaudichaudii R. Br.—a supposed natural hybrid, G. laurifolia × G. acanthifolia. By Dr. J. McLuckie (Visitor).

The interest in natural hybrids arises principally from their probable significance in Evolution.

A series of factors or conditions appears necessary for natural hybridization to happen, namely (1) proximity of the potential parents, (2) reasonably close blood-relationship, (3) absence of lethal pollen or stigmatic surface, (4) presence of the necessary pollinating agent. The absence of any one factor will act in a limiting manner ; *e. g.*, in the Sandstone Flora of eastern New South Wales, *Grevillea sericea*, *G. buxifolia*, and *G. punicea*—three clearly defined species—occur in the same community, flower at the same time, have the same pollinating agents, yet apparently do not hybridize naturally. The limiting factor here is probably a lethal stigma.

The majority of natural hybrids are intra-specific ; but inter-specific hybrids are common, especially in New Zealand flora ; inter-generic hybrids are infrequent, according to our present knowledge. The hybridizing species do not always belong to the same growth-form, for an arboreal will hybridize with a shrubby species, a prostrate with an erect shrubby

species. Generally the hybrids are polymorphic, and in F_2 and subsequent generations appear to segregrate towards one or other parent.

Known natural hybrids are rare in the Australian flora, a feature which is probably unexpected, and in contrast with the prevailing condition in the New Zealand flora. But in large genera like *Eucalyptus* and *Acacia* there are species with many recorded varieties, and groups of species which apparently merge into each other ; this probably indicates hybridity.

Grevillea Gaudichaudii R. Br. was collected by Gaudichaud in 1819 in swampy areas on the Blue Mountains (N.S.W.) ; also by Cunningham, who named it *G. acanthifolia* var. *quercifolia*, thus showing an observed relationship. Robert Brown named the species and described it. Later, Bentham described the species from the above and other material : these descriptions differ in important respects, and this seems to suggest that the material was very variable—in fact, the variability was greater than one might expect in the individuals of a species growing in the same habitat, and even greater than one finds when edaphic factors intervene. Fletcher and Musson (L. S. N.S.W. 1927) on morphological and taxonomic grounds concluded that *G. Gaudichaudii* R. Br. is a natural hybrid between the putative parents *G. laurifolia* × *G. acanthifolia*.

All these " species " occur in valleys on the Blue Mountains (N.S.W.) ; *G. acanthifolia* occupies swampy habitats, but is not confined to the montane zone ; *G. laurifolia* occurs *only* on sandy and gravelly habitats on the slope of these montane valleys, and on plateaus ; *G. Gaudichaudii* occurs *only* when both parent species are present, and is always closely associated with the *laurifolia* parent. The natural cross appears, from the facts of distribution, to be *laurifolia* (♀) × *acanthifolia* (♂). The present species are strongly contrasted in habitat, habit, and morphological characters, and a detailed examination readily reveals the relationship of the *G. Gaudichaudii* individuals to the parents. The *laurifolia* characters are :—prostrate habit, entire ovate-lanceolate foliage, prominent veins, intra-marginal vein, tomentose adaxial surface of leaf, short secund spikes, red flowers, short ovate bracts, ferruginous inflorescence hairs, yellow pollen, etc. ; the *acanthifolia* characters are :—erect spreading habit, strongly pinnasected foliage, indefinite veins, no intra-marginal vein, glabrous or slightly hairy adaxial surface of leaf, long spikes, pink flowers, long, lanceolate floral bracts, whitish inflorescence hairs, dark red pollen.

In nature two distinct types of *G. Gaudichaudii* occur : (*a*) an intermediate type, approximating closely to the mid-parent (H_1) ; (*b*) a type which approaches closely to the *laurifolia* parent, and may on *casual* examination be regarded

as a *laurifolia* plant, until the divided lamina indicates its probable character (H_2).

In all, approximately 35 characters have been examined in detail. Some characters are not measurable except qualitatively, *e. g.*, colour, hairiness, etc., but about 23 measurable characters were also studied. The mean of a large number of characters was obtained, and (following Warren, 1927) the coefficient of divergence calculated for the two types of *Gaudichaudii*, with respect to the two parents and the mid-parent, for each character. The coefficients of divergence for the intermediate type (H_1) of *Gaudichaudii* are $\frac{L-H_1}{L-A}$, $\frac{M-H_1}{L-A}$, and $\frac{A-H_1}{L-A}$ (where L=mean of the *laurifolia* character, M=mid-parent's character, A=mean of *acanthifolia* character), and for the other type (H_2) $\frac{L-H_2}{L-A}$, $\frac{M-H_2}{L-A}$, and $\frac{A-H_2}{L-A}$.

These coefficients are arranged in order of magnitude, and their sign indicates the direction of the hybrid's divergence from either parent and from the mid-parent. The coefficients are plotted about the mid-parent as a reference line, and thus a graph is secured which shows the relationship of the *Gaudichaudii* types to the parents and mid-parent. The graphs of the H_1 and H_2 forms are clearly contrasted, the former being evenly balanced about the mid-parent, thus indicating equal dominance of the parents; the latter showing strong asymmetry about the mid-parent and the strong dominance of the *laurifolia* parent. The graph of the H_2 type is similar to that which would be expected if it were a back-cross *laurifolia* (♀)×H_1(♂).

Hybridization experiments are in progress.

So far seed from the following crosses has been secured :— (a) *laurifolia* (♀)×*acanthifolia* (♂), (b) *laurifolia* (♂)×*acanthifolia* (♀), *laurifolia* (♂)×H_1(♀), and from selfing of the parents and H_1 and H_2 forms.

Seedlings have been secured from the (a) cross; and a comparison of these with the wild plants of *G. Gaudichaudii* indicates that these are the H_1 type; the H_2 type has not yet been secured, while germination experiments so far have not yet given the H_1 or H_2 forms from selfed plants.

The first batch of seeds from the reciprocal cross did not germinate, but I believe one or two seedlings from subsequent seed have germinated.

The facts of distribution of the parents and of *G. Gaudichaudii*, the results of a detailed study of the contrasting characters of the parents and their inheritance by the supposed

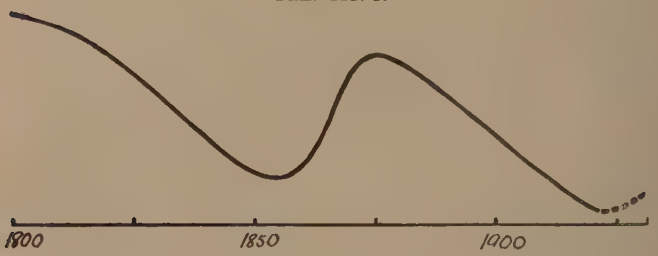
hybrid, and the fact that it is possible to produce *G. Gaudichaudii* by artificial hybridization experiments, seem to me to indicate the hybrid character of this so-called species.

The PRESIDENT expressed the thanks of the meeting to Dr. McLuckie.

Some Fluctuations in Zoological Populations during the Nineteenth Century. By B. Storrow, A.L.S.

The major changes which have occurred during last century can be indicated by fig. 1. The cusps and depressions may represent maxima and minima, but they also denote the periods of great change. The data considered relate chiefly to fisheries, and the fluctuations noted have been found to coincide with changed oceanic circulation and modifications of climate.

TEXT-FIG. 1.



The general tendency has been towards decreased salmon catches with a secondary maximum in the 'seventies and 'eighties. Early in the century the salmon left the southern North Sea; at the same time they were plentiful on the Irish Atlantic coast, and afterwards increased in some districts of that region. By 1812 the Tweed was definitely a grilse river, and later the Tay also; the disappearance of grilse from the Tweed after 1850 was followed by their increase about the north of Scotland; after 1900 grilse became fewer, and apparently, the centre of the North Sea grilse population, such as it is, is now southern Norway. Individual rivers vary considerably, and the Tyne, Coquet, and Tweed give local problems; their catches point to sympathetic fluctuations such as occurred for the Tay and Tweed about 1830, when decrease for the Tyne commenced. The widespread influence of factors is shown by the Thames, Hampshire Avon, and the Tweed in 1816, the last year when salmon made a serious attempt to enter the southern North Sea.

The herring fishery of the east coast of Scotland, which had previously had a history of trial and failure, came into being as an inshore fishery early in the century; it rapidly spread southward from Wick and yielded gradually increasing catches; the Beadnell fishery on the Northumberland coast commenced in 1827; bounties were dispensed with in 1830. The beginning of its prosperity coincided with the failure of the Swedish fishery centred about Gothenburg and the reappearance of the Norwegian spring fishery after an absence since 1785. In the 'fifties the July shoals of Wick were decreasing in importance; the Wick catches decreased, and in 1862 Cullercoats shoals were no nearer the shore than 14 fathoms. A concentration of shoals off the coasts of Aberdeenshire and Forfarshire, giving an offshore fishery, in the 'seventies and 'eighties, coincided with a general scarcity on other parts of the Scottish coast, the failure of the spring fishery of Norway, and the establishment of the Norwegian fat herring fishery; Swedish shoals made a spasmodic attempt at return, and the Cullercoats fishery failed. These changes were followed by increased catches from the Skagerrack, and our inshore shoals became of still less importance—the last to disappear was that of Craster Smooth about 1907, leaving the Northumberland fishery one of young developing fish and not of spawners.

Towards the end of the 18th century, when good catches were made occasionally at Yarmouth, the pilchard fishery was during August and September, whereas, previously, it followed the autumnal equinox. Early in the 19th century pilchards were common in the Firth of Forth at a time when the greater part of the Cornish shoals consisted of young fish. The disappearance from the Firth of Forth preceded increased Cornish catches about 1830. A period of comparatively low Cornish catches followed until the good years, 1845 to 1851. Afterwards there was a decrease, which, except for the three years about 1863, continued until the change which brought about the transitory maximum of the 'seventies. Thereafter the pilchard became less common.

The catches of tunny in the Portuguese fishery of Mêdo das Cascas decreased from the beginning of the century to the point of failure in 1845 to 1851. The high catches of 1870 to 1880 were followed by decrease. Records of tunny north of their centre of distribution are common in the first half of the century and also about 1870 to 1880.

Records by Day point to a northerly movement of southern fish in the first half of the century. In the 'seventies and 'eighties the records of Day and Smitt, for both northern and southern fish, indicate that individuals of various species were making abnormal migrations.

On the American side of the Atlantic the catches of

Newfoundland seals, which depend largely on the presence of ice, increased enormously in the early part of the century. Catches remained high until 1857, when, in spite of improved vessels and the introduction of steam, they decreased.

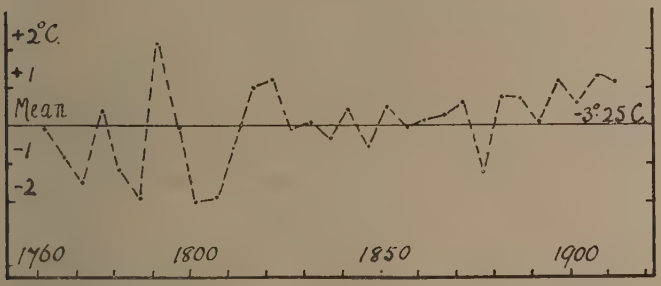
In the Gulf of Maine the general decrease of salmon commenced with the increased catches of Newfoundland seals, and coincided with high numbers of capelin and frequent records of basking sharks up to 1850. The factors which brought about this southerly movement of northern fish disturbed herring shoals: there was a marked decrease in catches, 1837 to 1857, and the establishment of new shoals on Georges Bank about 1850. Southern fish moved south in the first half of the century: the menhaden (*Brevoortia tyrannus*) left the Bay of Fundy, the chub mackerel (*Pneumatophorus colias*) disappeared, the striped bass (*Roccus lineatus*) left Androscoggin Bay and became less plentiful about Cape Cod, the weakfish (*Cynoscion regalis*) left Martha's Vineyard, and the torpedo (*Narcacion nobilianus*) gave few records after 1824, though previously common. After a period of violent mackerel fluctuations, 1851 to 1879, and with the establishment of a short period of regular migrations giving a wealthy fishery, 1880 to 1885, some of the southern fish returned. Menhaden became abundant and chub mackerel were not uncommon: the weakfish, appearing first off southern Massachusetts, rounded Cape Cod at the height of the mackerel prosperity; it was present in Massachusetts Bay in 1910: afterwards it decreased, and records of capelin and basking sharks became more frequent.

The changes which occurred about 1870 to 1880 coincided with many abnormalities in northern Britain, including a vole plague and variations in the appearance of swallows. The oyster beds of the Firth of Forth and Holy Island disappeared, those of the southern North Sea increased in importance, and the spatting seasons in the Thames estuary became changed for the better. For our country the change in the yield of wheat per acre coincided with change in the yield from the experimental plots of Rothamsted, and these with a difference in seasonal rainfall. The latter coincided with changes in the oscillation of the Icelandic low pressure area—the westerly departure becoming less after 1883, and its maximum position occurring, in a general way, from January to April. Mohn's investigations indicate a strong surface current along the Norwegian coast, and this, combined with great tidal range, coincided with records of peculiar icebergs (probably originating from the Siberian coast) and a Spitsbergen cod fishery. The November temperatures of Edinburgh increased after 1880 and those of Buenos Aires decreased after 1885; these changes coincided with an improvement in the winter temperatures of New York.

The widespread temperature changes indicated above suggest that the South Equatorial Current had increased its contribution to the North Atlantic and that the axis of the Gulf Stream was nearer the American coast. Such a change in circulation may have been assisted by a steeper gradient between the Azores High and the Icelandic Low; but a strengthening of the South East Trades or their more northerly position, depending on the intensification of the South Atlantic high pressure area or its more northerly position, would alter the axis of the South Equatorial Current with respect to Cape San Roque.

Records of frost, the filling of icehouses, and the winter temperatures of Stockholm indicate an amelioration of winter climate along the European Atlantic coast during the century—a change which could be produced by a northerly movement of warm waters.

Text-fig 2.



A number of warm winters at Stockholm preceded 1800, and from 1810 to 1825 the departure above the mean was considerable; the first tunny was recorded from the west coast of Norway in 1788 and one from the north of Iceland in 1814. The Arctic was changed: Scoresby experienced open seasons from 1813, and he estimated that 2000 square leagues of ice disappeared in the years 1817 and 1818; the east coast of Greenland was seen from open waters, the first time since Hudson's voyage of 1607: Kotzebue sailed from the Baltic to Bering Strait, and Scoresby surveyed 400 miles of the Greenland coast.

The Stockholm winters became colder after 1825, but they were considerably warmer than those before the beginning of the century; the departures from the mean gradually became less, and the general tendency was towards amelioration. In the period about 1870 there were high winter temperatures and violent departures from the mean. Since 1880 there has been gradual improvement, with comparatively few years

when the mean was below that for the period 1757 to 1914. The general tendency of change in Stockholm winters is shown in fig. 2.

Norwegian glaciers shrank during the century. Helland-Hansen's and Nansen's temperatures for the Norwegian Sea, 1900 to 1904, do not agree with those taken by Phipps, 1773, and the difference points to a gradual increase ; those taken by Scoresby indicate the warm water which brought about the clearance of ice.

At the beginning of the century southern fish moved northward, the pilchard reaching Yarmouth and later the Firth of Forth. The opening of the Arctic coincided with changes in the concentrations of herring shoals, alterations in the numbers of grilse, and, immediately preceding the great clearance of ice, the last serious attempt was made by salmon to enter the southern North Sea, 1816. Changes on land continued to coincide with change amongst marine fishes. When the South Atlantic increased its northerly flow there were violent climatic fluctuations, during which records of rare fish suggest rebounds from the Arctic ; European fisheries changed again, the cod reaching Spitsbergen in quantity. A period of gradual amelioration followed and fisheries changed gradually.

Warm water made its way north along the European coast. Any increase of waters entering the Arctic must be compensated by an intensified Labrador Current—the product of the East Greenland and Davis Strait Currents—and this would affect the American coast. In addition to the changes in the seals of Newfoundland and the fish frequenting the Gulf of Maine, the climate of New York altered in the first half of the century so that the European vine ceased to crop and later ceased to grow. Changed oceanic circulation in the region of the Equator after 1870 benefited the North Atlantic ; New York winters tended to become warmer, southern fish returned to the Gulf of Maine, and the winters of Stockholm greatly improved. That still further change has taken place is indicated by the fact that American hydrographers will not admit that the Labrador Current now contributes directly to the Gulf of Maine.

During the century the tendency was towards the opening of the Arctic, and, since the period was wet also, south-westerly winds must have predominated. The Icelandic Low and not the high-pressure area, Siberia–Azores, had the greater influence, but alternating periods appear necessary for the northerly spread of warm waters. This spread of warm waters is more general than here indicated, and the approximate periods of its maximum northerly extension are denoted, probably, by the cod fisheries of Davis Strait, which depend on the

presence of an undercurrent of warm Atlantic water; their recent productivity has followed changes in European fisheries which have coincided with biological evidence of a northerly movement of Atlantic waters: they were productive from 1845 to 1849 and about 1820. The oxygen values, obtained during the recent German Atlantic expedition, suggest, even more than do temperature data, the possibility of northern waters being affected by an undercurrent originating from the surface waters about the Equator. The change during the century indicates a very long period of alternation which depends on oceanic circulation—the great difference being the relative strengths of the North Atlantic Drift and the Gulf Stream, due to variations in winds and the locality and intensity of pressure areas.

Our fisheries are in an intermediate region between the influence of the Arctic and the Gulf Stream—the region of the North Atlantic Drift. In such a change as here indicated the tendency will be for the intermediate region to increase; its waters, cooled by the Arctic and added to by ice and the waters of Arctic rivers, circulate in the region save for that which sinks and travels as an undercurrent towards the Equator. Northern fish will go north and southern fish, first moving northwards, will be pushed south later; catches may decrease because of greater area and not smaller population. As the North Atlantic Drift becomes of greater importance, and during periods when the circulation increases through the Arctic—thus lowering the salinity of Drift waters—the relationship of the Drift waters and the northerly extension of warm water from the Equator is altered, warm equatorial water becomes an undercurrent at a lower latitude and the position of the undercurrent is deeper. The character of the Drift water becomes altered and other changes in circulation are possible. The behaviour of oysters and the way *Acmæa testudinalis* advanced southward, previous to the failure of our northern oyster-beds and decreased Norwegian yields, suggest an alternation in the strength of the currents entering the North Sea by way of the Channel and the north of Scotland. Such an alternation would alter things as widely different as the formation of the Dogger Bank and the plaice population of the Continental shallows.

With such changes of waters, distribution becomes altered and the incidence of fisheries changes in position and also time. The decrease in grilse suggests a change in migrations with respect to age. The general decrease in salmon may be due, in part, to decreasing reproductive powers, and not wholly to the action of man: if so, the introduction of one of the Pacific salmon becomes worthy of consideration. That changes in waters have been followed by changed migrations

of adults, difference in age at first maturity and the entering of commercial shoals, as well as physiological change—indicated by the results of normal curing—is evident from recent work on herring. At the beginning of the nineteenth century it was held generally that salmon spawned in November, and, for both the Tweed and the Tay, there are records of spawning becoming later shortly afterwards; during the period of secondary salmon maximum the Usk became an earlier river for spawning than formerly.

The action of a minor cause during a period of change will depend on the relation of conditions of the moment to the optimum condition for the species: whatever produces a favourable fluctuation by inducing approach to optimum conditions early in the period may have a reverse effect later because it induces departure. Minor causes acting during change will not be manifested in catches according to the true periodicity of the causes, but according to their relationship in approaching or departing from optimum conditions: fluctuations in catches may therefore become incapable of representing clearly the cause. Manifestations of fluctuations alter in position in an intermediate and changing area.

Dr. G. P. Bidder considered that much gratitude was owing to Mr. Storrow for his daring essay in an extremely important and extremely neglected branch of biology. Every zoological observer has been interested and puzzled by the unexplained changes between rarity and frequency in this or that animal; yet the speaker could not remember any previous attempt to give a conspectus of such changes and a correlation of their dates with those of changes in oceanic physical conditions. How much time must elapse between such a first essay and complete understanding may be judged from our progress in meteorology—though 60 years have passed since Francis Galton systematised meteorological analysis, the daily forecast is still far from infallible. In meteorology the difficulty of forecasting is largely due to the rarity of repetition of conditions, owing to the fact that we live on a globe covered with an irregular pattern of earth and sea, which rotates under the tide-producing moon and the tide- and heat-producing sun. Not only is the path of a disturbance deflected differently according to its crossing the west Atlantic in sunshine or in night-time, but a slight quantitative difference in the deflection will lead the path to such a different coast-line on the east Atlantic that the resulting event in Europe will be qualitatively different.

All these meteorological difficulties in correlating ultimate with antecedent phenomena are repeated in the science

which Mr. Storrow has attacked, and are, as it were, squared in numerical magnitude by addition of the large biological consequences of small meteorological changes.

In regard to Mr. Storrow's graph of the changes in fish populations, Dr. Bidder was unable to find in them any trace of O. Petterson's 93-year tidal period. He asked Mr. Storrow whether we should be right in gathering that Mr. Storrow's investigations are definitely opposed to this being traceable as a cyclical period in the growth and decline of the marine population ?

Mr. H. W. Pugsley remarked that a herring fishery was carried on from the ports of North Devon until about the year 1860, when the herrings deserted that coast.

The President, after expressing the thanks of the meeting to Mr. Storrow, expressed a doubt whether the introduction of any species of Pacific salmon, as suggested by Mr. Storrow, was desirable. The acclimatization of the Trout in New Zealand does not appear to have been an unqualified success, and there is already reason to believe that it has adversely affected the native fauna. The establishment of Pacific salmon in the Atlantic might prove disastrous to some of our fisheries, including that of the Atlantic Salmon, a species which is of superior quality as an article of food. Mr. Storrow had brought together a valuable mass of evidence with regard to fluctuations in fisheries, and it might be advisable to ascertain whether the records of Cetacea in European waters show similar periodicities. The Biscay Whale or Nordkaper (*Balæna glacialis*) seems to be specially worth considering in this conexion. It was hunted on the European coasts, particularly to the north of Norway and in the Bay of Biscay, many centuries ago. Its pursuit had been practically given up, on this side of the Atlantic, by the end of the 17th century. On the eastern coast of the United States considerable numbers appear to have been caught from about 1690 to 1700. The Biscay Whale had become scarcer, off the New England coast, by 1748, and its capture in that neighbourhood was practically at an end by the close of the 18th century. For nearly a hundred years it was supposed to be excessively rare, if not actually extinct. In 1882 a specimen was reported from off the Spanish coast, and from 1889 onwards a moderate number were caught in the neighbourhood of Iceland and the species was observed off the Färoe Islands. In 1906 and later years a considerable number have been caught in northern European seas, particularly off the Outer Hebrides.

There is no reasonable doubt that the falling off in the captures of the Biscay Whale was due largely to excessive hunting, but the question arises whether its recent appearance

in our waters is in any way connected with the results at which Mr. Storrow has arrived with regard to the history of the fishing industry.

In reply, Mr. Storrow stated that he drew attention to the shortage of salmon now experienced, and also that the Pacific salmon need not necessarily compete with ours in the rivers : the humpback could be expected to utilise our smaller streams, which, at present, produce neither salmon nor trout.

8th January, 1931.

Sir Sidney F. Harmer, K.B.E., F.R.S., President, in the Chair.

The Proceedings of the previous Meeting, held on Thursday, the 4th December, 1930, having been circulated, were taken as read and confirmed.

A list of names of those who had made gifts to the Library since the previous meeting was read and laid on the table.

The President stated that he regretted to inform the meeting that the Treasurer was too unwell to carry on his usual duties, and that Mr. Francis Druce had kindly consented to act in his place in the mean time.

The President called attention to an appeal made by the British Association for the Advancement of Science to residents in London to offer hospitality to those attending the Centenary Celebrations in September next.

The following Fellows signed the Obligation in the Book of the Charter and Bye-Laws and were admitted :—Elaine de Sainte Croix Fogg, Henry Arthur Potter, Walter Woodward Allen.

Certificates of recommendation of the following candidates for Fellowship were read :—For the second time, in favour of Isabella Gordon, Arthur Erskine Ellis, and John Joseph Sheldon.

A Study of Ranunculus parviflorus L., with special reference to its morphology and ecology. By Professor E. J. Salisbury.

This species is shown to have a leaf arrangement consistent with the hypothesis that the apical meristem is the multicellular equivalent of a three-sided apical cell. The real divergence between successive leaves is shown to be very variable, but consistent with displacement of a spiral sequence having three members in each completed circle of the stem.

The floral structure has been studied in its entirety in 725 flowers, and in a considerably larger number with respect to special features. The anatomy of very young flower-buds exhibits a trimerous organisation, and the most frequent number of parts in the flower as a whole is 26 (222 examples). The quincuncial calyx is held to represent two trimerous whorls in which an outer and an inner member are congenitally fused. Hence in a trimerously organised flower the total number of parts is a number one less than a multiple of three. The structure of the sepals and their variation indicates their origin from leaves, and that the sepal is the equivalent of the leaf-base.

A negative correlation coefficient of 0·36 with a probable error of 0·0218 is found for the number of stamens and number of petals. Taken in conjunction with the spatial relations and the occurrence of transitional types, the staminodal nature of the petals is clearly indicated. The petals attain maturity after the stamens, which may be associated with their, phylogenetically, more recent origin. Altogether 116 different types of floral organisation were represented, and the observed range in numbers of parts was as follows : –K. 4–5, C. 0 5, A. 1–8, G. 3–18 ; (the most frequent conditions being K. 5, C. 2–3, A. 4–6, G. 12–14). There is a slight negative correlation (0·062) between A. and G., possibly a consequence of a very pronounced protandry. It is in harmony with the trimerous organisation of the flower that the vascular supply of the carpel is relatively unspecialised.

The archesporium of the ovule may consist of a single cell or may be multicellular, and a tapetal cell, a rare condition in Ranunculaceæ, may be cut off. The ovule, which is at first orthotropous, and anatropous at the time of pollination, becomes more or less campylotropous after fertilisation. The ovular trace may be given off at the same time as the two lateral ventral traces, or it may arise from one of these. Thus in several respects the ovule of this species exhibits what are probably to be regarded as primitive characters, which is in harmony with marked trimery of the gynæceum.

The structure of the epidermis, the structure of the stomata, the stomatal index, and the anatomy of the leaf and root, all suggest a plant of damp rather than dry habitats. This is in conformity with the "atlantic" type of distribution of the species and its southern habitats. Experimental cultures show that the species does not grow so well on dry sandy or calcareous soils as on moist loam. Its association with dry habitats towards its northern limit is probably conditioned by greater frost resistance on these soils and relief from the pressure of competition.

The species is shown to be a " winter annual " with " simultaneous " germination in September. In consequence of this and its susceptibility to frost the species may become completely exterminated from a locality by severe cold. Its absence from Central Europe may be correlated with the liability of severe frosts in a continental climate.

Mr. I. H. Burkill referred to an investigation made in 1897 upon the flowers of *Ranunculus arvensis*, wherein the parts of all the flowers produced by a bed of plants were counted, and results obtained as follows :—average number of organs just under 22 ; flowers with 20 organs approximating to the formula $K_5C_5A_5G_5$, but petals rather below 5, with a compensating fraction for stamens above 5 ; and no indication of trimerous whorls. He hazarded that perhaps *R. parviflorus* exhibits a tendency to settle into such trimerous whorls which is not shown by *R. arvensis*, and in connection with trimery in the Ranunculaceæ, referred to the frequency of these in the carpels in *Aconitum* and *Delphinium*.

He recalled Gerard's cure for the toothache by blistering with *Ranunculus*, and said that his fingers had been blistered in the examination of flowers of *R. arvensis* preserved in alcohol.

Mr. W. C. Worsdell stated that he had only once found *R. parviflorus* –by a roadside in Devon. The sepals may be derived from stamens in some groups, but not in others, though there are many plausible arguments for their derivation from leaves or bracts. Quincuncial arrangement of perianth leaves, as derived from two whorls of three, can be found normally in Polygonaceæ, and abnormally in some Monocotyledons, *e. g.*—*Crocus*, the Tulip, the Lily, etc.

Dr. T. A. Sprague pointed out that the statistics given by Prof. Salisbury suggested that meristic reduction has taken place in geometrical progression. He raised the question whether the application of the terms sepals and petals was not partly a matter of convention. He enquired whether Prof. Salisbury regarded the perianth of *Anemone* as a calyx or a corolla.

Mr. H. Stuart Thompson asked if there was any evidence of *Ranunculus parviflorus* having in remoter times extended any further eastward in France or even into Central Europe ?

Prof. Salisbury replied to the questions.

The President expressed the thanks of the meeting to the author.

Mr. H. W. Pugsley exhibited specimens of four species of *Euphrasia*, described in his paper recently published in the Society's Journal. Of these, *E. latifolia* Pursh ex Wettst.,

which has an almost circumpolar distribution and is widely spread in Scandinavia, is found to be of frequent occurrence on the higher Scottish mountains. The diminutive *E. cambrica* Pugsl., which appears to take the place of *E. latifolia* in the Snowdonian region, was also shown, as well as two distinct endemic species from the north coast of Scotland, *E. rotundifolia* Pugsl. and *E. Marshallii* Pugsl.

Examples of a new endemic species of *Limonium* were also exhibited. This plant, which grows on the archæan rocks of the coasts of Pembrokeshire and Donegal, is remarkable for its anomalous subcapitate inflorescence, which in some measure indicates an approach to the form of inflorescence characterising the genus *Armeria*. An account of this species, with figure, will be published in the 'Journal of Botany' for February 1931.

A further exhibit was a sheet of *Juncus alpinus* Vill. from Teesdale. The exhibitor remarked that this rush had apparently not been previously recorded for England, although known from Scotland, and that it belonged to the central European form of the species rather than to that found in Scandinavia.

Mr. J. S. L. Gilmour made the following remarks on *Typha minima* Funk in Britain :—

While going through the herbarium of the late Arthur Shrubbs, for many years assistant in the Cambridge Botany Museum, I found a sheet of *Typha minima* Funk (labelled as a small form of *T. angustifolia* L.) collected in Wicken Fen, Cambridgeshire, in July 1893. This species has never certainly been found in Britain before. It is possible, but very improbable, that Shrubbs mixed up some foreign material in his herbarium, and the record cannot be accepted without reserve unless the plant is refound. The present species is very different from any form of *T. angustifolia* L., being much smaller in all its parts, with very narrow leaves, a shortly cylindrical female spike at some distance from the male, which often has a leaf at its base, and a glabrous axis ; it flowers two months earlier than *T. angustifolia*.

It grows by rivers and in boggy meadows in alpine valleys of south-eastern Europe, extending down the rivers, westwards to the Rhone at Lyons, Arles, and Avignon, and northwards to the Rhine just south of Heidelberg ; it occurs all over Italy, and from there eastwards through the Balkans and southern Russia to western Kansu and northern China. From this distribution it would not be a likely plant to grow in Britain.

Previous to this record, there have been several reports of its occurrence in Britain. Parkinson, in his 'Theatrum

Botanicum,' published in 1640, describes three species of *Typha* from Britain. His figures and descriptions are very vague, and do not form a definite proof of the presence of the plant in Britain at that time, though one of his figures is not unlike this species. In 1724 Dillenius gives a record for this species, in his edition of Ray's 'Synopsis,' on the authority of Samuel Doody, who says it was "found by Mr. Dandridge on Hounslow Heath where the Sium alterum Olusatri facie [*Cicuta virosa*] grows." No specimen was preserved and it has never been found there since. This record was copied into all the British Floras after 1724 until towards the middle of the 19th century, when it was gradually dropped out and is now never quoted. During the 19th century four other records appeared—but all either incorrect or very doubtful. One from near Liverpool has proved to be small *T. angustifolia* on examination of the specimens in the Liverpool Museum Herbarium; there are three others from Kent (see Druce, "Dubious Plants of Britain," Rept. B. E. C. 1919, p. 790), all very doubtful.

A thorough search will be made this summer for the plant at Wicken Fen in the hope of confirming the occurrence of this unexpected species in Britian.

Mr. A. J. Wilmott first exhibited specimens of the discoveries made by Prof. Fernald, of Harvard, while visiting this country in connection with the International Congress at Cambridge. The first three species mentioned were found during a short visit to Kinlochewe in West Ross at the south end of Loch Maree. *Eriophorum opacum* (Bjornst.) Fernald, formerly misidentified in eastern N. America and Scandinavia with the Alaskan *E. callithrix*, and a close ally of *E. vaginatum*, was found sparingly in some mountain rills. It will probably be found elsewhere now that attention has been drawn to it. The sheet exhibited, presented to the British Museum Herbarium by Prof. Fernald, contains most of the material collected by him. *Antennaria hyperborea* Don was seen and two sterile rosettes picked for record (one of them shown): further search was not made as it was presumed to be common, although our only certain records were for the Isle of Skye. *Scirpus Hudsonianus* (Michx.) Fernald (=*Eriophorum alpinum* L.) was also noted by Prof. Fernald, but it is so common in north-eastern America that he did not trouble to preserve a specimen, presuming it to be equally common here. Specimens collected by Robert Brown, who with Don discovered it in its only certain British station in Forfarshire—where it was long ago destroyed by digging—were exhibited. The existence of other doubtful records for the British Isles was mentioned. *Juncus Dudleyi* Wiegand—an ally of *J. macer* S. F. Gray

(*J. tenuis* auct., non Willd.), for which it was mistaken by the late Mr. C. E. Salmon near Crianlarich in Sept. 1915—was identified by Prof. Fernald during his visits to the British Museum Herbarium. The sketch of *Spiranthes stricta* (Rydb.) Nelson made by the Lady Strathcona from a specimen found in Colonsay, was exhibited with a fragment of the plant. All these records have been dealt with in the 'Journal of Botany.' *Empetrum hermaphroditicum* (Lge.) Hagerup, studied by Mr. Trapnell during his visit to Greenland, was discovered by him in Snowdonia on his return. Specimens collected by him there, and others from the Sow of Atholl, Perthshire, (collected by the exhibitor), were shown. The British Museum Herbarium contains specimens from the following additional localities :—Perthshire : Ben Lawers (monœcious specimens) ; Aberdeenshire : Lochnagar (Joseph Gedge, Aug. 1864) ; also Croall, Plants of Braemar, No. 431 ; E. Inverness : near Kincraig (A. Somerville, 1891) ; W. Ross : Ben Slioch (G. C. Druce) ; and W. Sutherland : Ben Hope (E. S. Marshall, 25.5.1900) ; and probably a specimen from Arran (collected by " Bell "). The tiny fragment labelled by J. Salisbury as " *Empetr. scoticum* Gwythir 19 Martii " and now in Herb. Mus. Brit. does not at present appear to possess a hermaphrodite flower, but it has the habit of *E. hermaphroditicum*, and in addition was acquired with the drawing (MSS. V. 552) of a hermaphrodite flower bearing this same locality and date. This name, *E. scoticum*, was incidentialy mentioned by Hooker in 1830 (Fl. Brit. ed. i. 434) as follows :—" A smaller bushy *var.* is cultivated in gardens, under the name of *E. scoticum*, on which I have found perfect flowers "—but as this does not constitute valid publication of a name, *E. scoticum* cannot replace *E. hermaphroditicum*.

Mr. C. G. Trapnell pointed out that *Empetrum hermaphroditum* Hagerup was found between 2,300′ and 3,400′ at various points on the Snowdon group ; these plants being recognised from their likeness to the Greenland plant of this species. The plant occupies a large sector of the Arctic, and is comparatively uniform throughout. Variations at points of contact with the other species made it necessary to take all characters and not sex alone into consideration of its identification.

Mr. E. G. Baker mentioned some other new plants that had recently been recorded for Britain, three subspecies of *Myosotis versicolor* Sm., and some new roses from Northumberland by Mr. Heslop Harrison.

Prof. J. R. Matthews also made some remarks.

A vote of thanks to the authors, expressed by the President, concluded the meeting.

22ND JANUARY, 1931.

Sir SIDNEY F. HARMER, K.B.E., F.R.S., President, in the Chair.

The Proceedings of the previous Meeting, held on Thursday, the 8th January, having been circulated, were taken as read and confirmed.

The President announced the death of Mr. Horace Woollaston Monckton on the 14th January, 1931, and moved the following Resolution, which was passed in silence, all standing :—

> The Linnean Society of London having heard with the deepest sorrow of the death of Mr. Horace Monckton, for twenty-five years Treasurer, and for thirty-eight years a Fellow of this Society, desire to record their gratitude for the great services which he rendered to the Society and their sympathy with his surviving relatives and with his other friends.

A list of names of those who had made gifts to the Library since the previous meeting was read and laid on the table.

The following Fellow signed the Obligation in the Book of the Charter and Bye-laws and was admitted :—Marian Whelan.

A certificate of recommendation of the following candidate was read for the first time :—Ben Dawes.

The following candidates were balloted for and elected as Fellows :—Mandayam Osuri Parthasarathy Iyengar : Isabella Gordon, D.Sc., Ph.D. ; Arthur Erskine Ellis, B.A. ; John Joseph Sheldon.

Presentation by the Swedenborg Society to the Linnean Society of London.—A letter of Linnæus to Anders Ausenius. By Mr. J. R. Presland (Visitor, representing the Swedenborg Society).

Mr. President, I have the honour, on behalf of the Council of the Swedenborg Society, to bring a letter recently found among its papers. How the letter came into our possession is not known, but when the Council was made aware of its contents it was felt that it should find a place in your archives rather than in ours.

The translation from the Swedish of this letter is as follows :—

Rector the learned and reverend Herr Doctor ANDERS AUSENIUS,
Hökkesund u/ Årkestiflit.
Learned Herr Rector,

I have received your esteemed letter through the Doctor Herr Arken, and tender sincerest thanks for the same.

I have proceeded with all possible care to get together the desired plants, and have had good help from Assistant Ramberg.

The specimens I am preparing for Herr Rector Littils amount to 644 numbers, and should be in my friend's and colleague's hands within eight days

I remain with all devoted friendship,
Learned Herr Rector's humble servant,
CARL LINNÆUS.

Upsala, 1750
the 12 March.

I am to have the privilege of addressing your briefly on the personal contact that existed between Linnæus and Swedenborg.

Linnæus was born in Rashult, Sweden, in 1707. Emanuel Swedberg, who after he was ennobled in 1719 was known as Swedenborg, was at that time nineteen years of age, his birth having taken place at Stockholm in 1688.

It was at one time thought that the two men took no notice of each other's labours. Later researches show, however, that this view, to which expression is given in Dr. Tafel's "Documents concerning Swedenborg," was mistaken. Linnæus was a Foundation Member of the Royal Academy of Sciences, Sweden. It was he who, on the 26th November, 1740, proposed Swedenborg for membership. The proposal was accepted and Swedenborg took his seat on the 8th January, 1741. There is still, in the Library of the Academy, a manuscript which, apparently, is that of the short speech he made on the occasion. It is marked "Swedenborgs Intradestal i Svenska Vetenskaps-Akademien den 8 jan. 1741." Further you have in your Library a copy of Swedenborg's work "Om Jordenes etc" ("On the Motion and Position of the Earth and Planets")—a copy which has copious additions in manuscript. This copy was found in Linnæus's Library, and it has a plate that, in the view of Dr. Alfred Acton, was drawn by Swedenborg himself. If so, you have here a unique copy; for Hyde, in his "Bibliography of Swedenborg's Works," states "No copy yet found contains the plate to which the text refers."

The two men were related by marriage. Linnæus, in 1739, married Sara Elisabeth, eldest daughter of Johannes Moræus, who was a first cousin of Swedenborg. At the time of this marriage Swedenborg was in Italy or France, engaged in the preparation of his "Œconomia Regni Animalis" published in 1740. During the greater part of 1740 he lived in the same town as Linnæus, Stockholm. In 1741 Linnæus removed to Uppsala as a professor; here Swedenborg, years before, had taken his degree of Doctor of Philosophy. Owing to the fact that both men travelled extensively (Swedenborg throughout his life), they were rarely, if ever, domiciled near together at any other period than 1740.

There is evidence that in his early years Swedenborg had given some attention to the subject which made Linnæus famous. This is clearly brought out in that three-volumed edition of his scientific works that was issued in the years 1907, 1908, and 1911 under the auspices of the Royal Academy of Sciences of Sweden. In vol. i. Prof. Alfred G. Nathorst remarks:—

> The circumstance that Swedenborg was the first Swede who described plant-fossils and interpreted them in a manner satisfactory for those times, led me as long as 30 years ago to name a genus of fossil plants (*Swedenborgia*) after him. It may also be mentioned in this connection, that in the State Museum for Natural History at Stockholm, in the department for fossil plants, there is a fossil tree-trunk of some size, 0·85 m. high and 0·3 m. in diameter, which bears a printed label reading: 'Petrified tree-trunk. East India. From Em. Swedenborg's collections . . .' There is unfortunately no further information concerning this trunk beyond what the label supplies; the trunk comes from the museum's older collections. Even with a magnifying glass it may be observed that an angiosperm is in question, but no microscopical investigation of it has thus far been carried out.

His approach to the subject was, however, rather that of a mineralogist than of a botanist. You will remember that he was an Assessor in the Royal College of Mines. His interest in plant life was not profound in a scientific sense. That he loved plants is true. His garden at Stockholm was one of his chief delights, and there is a note-book in which he recorded what he planted there and the dates of planting. But by the time his contemporary had reached to eminence, philosophy was engaging his attention, and, later, that system of theology by which he is chiefly known.

Samuel Sandels, Councillor of the Royal College of Mines, a member of the Royal Academy of Sciences of Stockholm, drew a parallel between Linnæus and Swedenborg when he read

in the House of Nobles a eulogium on the latter shortly after his death in 1772. Referring to the great research and literary output of Swedenborg he says :—

> Who else, except perhaps Linnæus, has given such an account of a journey abroad, and of one of so short duration ? For after an absence of a year and half he, in 1722, gladdened his country by his return.

Linnæus from a seat in the House may have heard this reference.

The remains of Swedenborg were laid to rest, in April, 1772, in a vault of the Swedish Lutheran Chapel, Prince's Square, in the east end of London. Less than six years later those of von Linné were placed in the cathedral at Uppsala. In 1908, at the request of the Swedish Government, the remains of Swedenborg were removed from their first resting-place and were deposited in a marble sarcophagus in a chapel exactly opposite to that in which stands the monument to Linnæus. There they were placed in the presence of the king, the archbishop, a great assembly of professors, of students, and of the people. The remains of two great sons of Sweden had thus been brought together ; he who sees the memorial to the one sees the sarcophagus of the other. Each contributed to the store of human knowledge, although their subjects of study were not the same.

Mr. President, I now ask that your Society will accept the letter I have the honour to offer you on behalf of the Council of the Swedenborg Society.

The PRESIDENT expressed the thanks of the Society to the Swedenborg Society for the donation, and the thanks of the meeting to Mr. Presland.

Vegetation in Godthaab Fjiord, West Greenland.
By C. G. Trapnell (Visitor).

The account given was based on observations of the Oxford University Greenland Expedition, which worked principally at Isersiutilik, 40 miles up Godthaab Fjiord, in lat. 64° 40′ N. in June and July of 1928. An ecological survey was made of an area of 8·3 sq. miles and extended by more distant reconnaissance. The special area was one of low broken fjaeld with gneiss exposures scoured by glaciation and traversed by chains of lakes. It lay in a region of balance between the foggy maritime regime of sea winds and late snow and the arid and sunny regime of the ice cap winds with little snow. The heaths here have an extremely variable " patchwork " structure, which often gives way to vegetation of a most heterogeneous character. Two of the causes of this were described :

(1) Multiplicity of habitat: The broken topography intensifies the effects of the low sun and the strong winds on the depth and duration of the snow, and leads to numerous small "local climates." There are also important grades of texture and drainage of substratum which developmental succession is insufficient to cover up. The vegetation thus varies principally according to the combinations of four series of factors, giving a very great number of different habitats.

(2) Competition: The vegetation consists principally of mat-forming shrubs, mosses and lichens, all of very close growth. The shrubs are seldom continuous owing to the competition of their long, horizontal roots, the spaces being occupied by the cryptogamic mat, while the moss extends under some of the shrub growth. Dying shrubs are likely to be replaced or suppressed by the moss and lichen mats, while their seed has its chances of establishment limited by their dense growth. The mosses may be converted into humus as their parts die off, but are usually encrusted by lichens. Of the latter, the dense *Cladina* mat sometimes dies out in patches or is cracked into polygons by the sun, when invasion is possible. There is thus a backward and forward warfare over the ground which is accentuated by the uncertainties of the climate, while the northern species are relegated to exposed situations.

In places where certain factors are more pronounced than usual small groups of plants become dominant, with one or two hangers-on dependant on them. Only in such places can communities be accurately distinguished, and they are too few to provide a means of classification of the whole heath vegetation. The heath is not a unit, but a mixture representing different habitats and different successional stages. It was thus suggested that classification should be based on an analysis of the habitat variation. To do this accurately winter measurements of snow depth and duration are necessary. But by plotting the various surface types against different aspects and degrees of exposure and alloting field data to their various combinations, certain common factors can be extracted, giving a series of plant groups for exposure changes, a series for aspects, and, to a lesser degree, series for drainage and texture of substratum. These series bring out particularly the aspect and exposure requirements of the small patch communities referred to, and their local climatic requirements so inferred are found to agree with their distribution in the Greenland coast belt and the observations made on their snow requirements by Porsild in the Disco region.

Prof. R. R. Gates stated that it was interesting to compare the conditions of the vegetation in West Greenland with his

own observations of the tundra in Russian Lapland and in the Arctic region of Canada around the mouth of the Mackenzie River. In both these areas the vegetation appears to be under less extreme conditions than in Greenland, which is nearer to the ice cap. The sharp transitions within very short distances, which Mr. Trapnell described, are very striking, but less marked transitions of a similar kind occur in the Canadian Arctic, some areas having a predominance of grasses, and others a predominance of lichens. Mr. Trapnell had mentioned the European *Betula nana* as present in the Greenland flora. In Arctic Canada its place is taken by *B. glandulosa*. Does *B. glandulosa* also occur in Greenland ?

Mr. R. Paulson remarked that the locality chosen for investigation proved to be abundant in lichen growth, but was limited to a few species ; the most frequent were *Alectoria ochroleuca*, *Cladonia mitis*, and *Cetraria nivalis*. If collected, the colour of some of the lichens on rocks would have been found to be bright-coloured, as e. g. *Caloplaca elegans*, *Xanthoria lychnea* and *Caloplaca murorum*. He compared some of the lichens having a coloured thallus and apothecia found in the Arctic and Antarctic regions ; some gradually lose their bright colouring in a latitude bordering on 80° N.

Mr. C. V. B. Marquand commented upon the number of problems of great interest to the ecologist and phytogeographer that had been raised by Mr. Trapnell. He asked whether lichens or bryophytes were the pioneer species in the succession leading up to the formation of the *Rhacomitrium* carpet illustrated in one of the lantern-slides shown ; also, whether the *Rhacomitrium* was torn up in sheets by the wind when sudden gales were encountered, as occurs on the plateau of the British mountains in the Arctic-Alpine zone as well as in parts of the Alps ? He also enquired whether the author had made observations on the species composing the communities found at the extreme upper altitudinal limit in this part of Greenland, and the approximate altitudes reached by phanerogamic and cryptogamic vegetation respectively in the district investigated.

In reply Mr. Trapnell said that *Betula glandulosa* replaces *B. nana* at about Lat. 63° N., occupying the region south of the Frederickshaab ice-arm. The change has the appearance of being due to immigration of the species from different points. A number of the American immigrants do not seem to have been able to occupy their full climatic range on the West Coast. The lichen *Alectoria ochroleuca* shows the loss of colour to which Mr. Paulson referred with increasing altitude in Godthaab Fjiord. It was difficult to infer the time succession that had taken place in cryptogams, as the space changes from which this might be inferred were subject to the great local variation described. Subject to this, the *Rhacomitrium*

mat appeared to succeed either *Gyrophora hyperborea* and various crustaceous lichens, or a variety of small mosses (*Pohlia* spp., etc.), usually lichen encrusted. The mosses of 2200 to 2400 ft. varied greatly, but *Andreæa crassinervia*, *Polytrichum alpinum*, *Bryum oxoniense*, and *Rhacomitrium fasciculare* were characteristic.

The PRESIDENT expressed the thanks of the meeting to the lecturer.

Burmese Charophyta. By Mr. B. P. Pal (Visitor).

[The author's abstract is as follows :—]

An account of an investigation into the systematics, distribution, ecology, and economic importance of Burmese Charophytes. Burma has a large number of species belonging to the genera *Chara* and *Nitella*, and these flourish chiefly between the months of August and March.

The principal ecological factor studied was the influence of pH of habitat on growth, and the results point to the conclusion that a high pH is favourable and a low, inimical. The importance of Charophyta as destructive agents of Culicid larvæ was negatived by experiments on *C. gymnopitys* and two spp. of *Nitella*. An apparent larvicidal effect in one case was discovered to be due to the presence of larvæ-eating insects.

Twenty-five species were collected altogether, of which ten are apparently new. *C. Wallichii*, *C. hydropitys*, *C. erythrogyna*, and *N. acuminata* are recorded for the first time from Burma.

Mr. T. B. BLOW said that the Society was much indebted to Mr. Pal for such a lucid account of his researches into the history of the Charophyta of Burmah : especially for his observation of the destruction of mosquito larvæ by predatory water insects concealed among the growing Charophyta, and his subsequent experiments proving how rapidly every larva is devoured by them, thus helping to solve one of the problems that has seemed to prevent the complete admission of the non-larvicidal qualities of Charophyta. This was generally accepted by all the British experimenters, but opinion has been disturbed by the very extensive experiments with *Chara fragilis* published by Matheson and Hinman in the ' American Journal of Hygiene,' in which they state that under every condition this plant is absolutely larvicidal. Though at least eight species had been tested in England, yet *Chara fragilis* was not one of these, and he (Mr. Blow) at once procured the plant, and using the larvæ of *Culex pipiens* and *Theobaldia annulata* found that they flourished extremely and over 90 per cent. attained the flying stage, the results thus being in complete contradiction to those of Matheson and Hinman.

As Dr. Hamlyn-Harris, the city entomologist of Brisbane, was also experimenting with *Chara fragilis*, he was only waiting for a letter from him giving his results before making a communication to the Society. Doubtless there are other causes, such as the presence in the water of substances inimical to mosquito larval life that have caused this credit to be unjustly given to Charophyta.

Mr. Blow further congratulated Mr. Pal on his successful field work in adding so many species new to science to the Burmah flora, and for his instructive slides showing these new plants.

Lt.-Col. J. H. Tull Walsh and Mr. I. H. Burkill supported the suggestion that the Charophyta have no larvicidal action.

The author replied, and a vote of thanks to him concluded the meeting.

5th February, 1931.

Sir Sidney F. Harmer, K.B.E., F.R.S., President, in the Chair.

The Proceedings of the previous Meeting, held on Thursday, the 22nd January, having been circulated, were taken as read and confirmed.

The President reported that he had received a letter from Miss Monckton, expressing her gratitude for the vote of condolence passed by the Society on the death of Mr. Horace W. Monckton.

The President announced his appointment of Mr. Francis Druce as a Vice-President of the Society.

A list of names of those who had made gifts to the Library since the previous meeting was read and laid on the table.

The following Fellow signed the Obligation in the Book of the Charter and Bye-laws and was admitted :—Mandayam Osuri Parthasarathy Iyengar.

Certificates of recommendation of the following candidates for Fellowship were read :—For the second time, in favour of Ben Dawes. For the first time, in favour of Niranjan Mukerjee and David Guthrie Catcheside.

Brachyura collected by Dr. Crossland on the 'St. George' Expedition to the Pacific, 1924–25. By Dr. Susan Finnegan.

[The following is the author's abstract :—]

The material considered in this paper was collected on the east and west coast of the Isthmus of Panama and as far

west as the Galapagos Islands. The results obtained are of interest in connection with the isthmian division of faunas and the problem of "representative species."

Sixty-five species of Crabs were collected, of which eight are new, and one new variety is described. In addition, the opportunity has been taken to analyse all the existing records of Brachyura from the region in question, and to attempt to identify the various geographical elements in the fauna. The chief conclusions are that certain genera may be regarded as typically American, and are represented on the two sides of the Isthmus by identical or closely allied species. So far as the scanty geological evidence goes, these genera do not date further back than the Pliocene. A number of identical species from the two sides are shown to belong to a circumtropical fauna. There is evidence that the similarity between the Indo-Pacific and Panamic faunas was greater in the past than it is to-day.

The PRESIDENT congratulated Dr. Finnegan on the interest of her communication, and on her success in finding useful specific characters. After expressing the thanks of the meeting, the President invited discussion on the paper.

Mr. T. B. BLOW asked what per cent. of the crabs recorded were swimming crabs, and whether these crabs were following shoals of migratory fish and preying upon them—as large numbers do when following the vast shoals of migratory fish that come up to the Pacific coasts of Japan at certain seasons of the year.

Mr. J. R. NORMAN stated that a comparison of the shore fishes of the two coasts of Central America showed that most of the species can be paired, one being found on the Atlantic side and the other (its nearest ally) on the Pacific side. In working on the Flat-fishes of this region he had found similar pairing in some genera. Only one species appears to be common to both Atlantic and Pacific coasts, but three or four are common to both the Atlantic coast of Central America and that of West Africa. These last are all species with a prolonged larval life.

Dr. G. P. BIDDER congratulated Miss Finnegan on her highly successful completion of work which he remembered being in its initial stages five years ago. Certain authors have claimed that the sponges of Australia show great resemblance to the sponges of the West Indies; is this true in regard to Brachyura?

Dr. ANNA HASTINGS said that in working on the Polyzoa of the Panama region she had looked for pairs of representative species without finding any, but the Polyzoan fauna of both sides of the Isthmus is so little known that this result is not conclusive.

Dr. FINNEGAN, in replying to questions, said that the Brachyuran fauna of the West Indies did not show as close an affinity with that of certain sections of the Australian region as is exhibited perhaps in some other groups of animals. Although one might well think that the distribution of swimming crabs would show a different range to that of other crabs, the data from the region in question was disappointing from that standpoint, as it showed very little discrepancy.

On the recently-discovered letter from Linnæus, dated 1750. By Mr. S. Savage.

At our last meeting a letter from Linnæus, dated 1750, was presented by Mr. John R. Presland as the representative of the Swedenborg Society. (A translation from the Swedish of the letter is given on page 37.)

Mr. Presland's paper on the personal contact between Swedenborg and Linnæus was of great interest, and I am able to add little to that side of the matter. I would first draw attention to the importance of the newly-discovered document itself.

This letter, written by Linnæus three years before the publication of his 'Species plantarum,' shows firstly that, at that period at any rate, he used to send named plants to his friends, and, secondly that, as a result, some of those small collections may be still in existence, either in private or public herbaria.

It has often been a matter for surprise to systematists consulting the Linnean Herbarium that the types of many of the species described by Linnæus are not to be found there. These omissions have usually been accounted for by showing that Linnæus wrote some of his diagnoses from the descriptions and illustrations in the works of other botanists prior to 1753. Gifted as he was with a very retentive memory it seems also not unlikely that he made full use of every specimen that ever came into his hands for determination and return to its owner. It would be of great interest if some of these small collections, with the determinations written in Linnæus's handwriting *, were to come to light.

Possibly some of our Swedish friends may be able to throw light on the identities of Dr. Anders Ausenius, to whom the letter is addressed, or of Rector Littils; from the context they seem not improbably two of the colleagues of Linnæus at Uppsala University.

With reference to the personal contact between Swedenborg and Linnæus,—the Linnean Collections do not contain any

* A very useful book might be published containing reproductions of the handwritings of all those who have been noteworthy for their work in the biological sciences.

letters from Swedenborg. The volume of opuscula to which Mr. Presland made reference, as containing an original drawing, for a plate, believed to be the work of Swedenborg himself, probably came into the possession of Linnæus through his father-in-law, Dr. Johan Moræus, who lived at Fahlun, one of Sweden's great mining districts, and was one of Swedenborg's early tutors in Uppsala. The volume does not contain any annotations by Linnæus, and the list of contents at the beginning is not in his handwriting, but may be in that of Dr. Moræus. That Linnæus received books from the library of Moræus is proved by the latter's signature on some of the titlepages.

At one time there was another item in Linnæus's library directly connected with Swedenborg. This is proved by an entry in Sir James Edward Smith's MS. Catalogue of Linnæus's books, where a volume of medical dissertations (probably by Hoffwenius, and so far as I am able to trace it, now at Linné's-Hammarby near Uppsala), is noted as bearing Swedenborg's signature on one of the titlepages.

Swedenborg was a man endowed with a powerful, many-sided intellect, devoting himself to Mathematics, Mechanics, Mining and Inventions generally; also studying Astronomy, Physiology, Chemistry and other sciences. In Biology he antedated by several years the theory of 'epigenesis' set forth in Caspar Friedrich Wolff's dissertation dated 1759. In Astronomy also he put forth theories that were taken up by later workers. His great engineering feat at the siege of Frederickshall in 1718, (when he arranged the transportation, by means of rollers, of two galleys, five large boats and one sloop, over mountains and valleys for a distance of fourteen English miles, thus enabling King Charles XII. to carry out his plans for the reduction of that almost impregnable fortress), reminds one of similar feats performed by Leonardo da Vinci, another great man of many-sided genius. When about fifty-five years of age, Swedenborg boldly crossed the frontier that divides Physics from Metaphysics; and henceforth, to apply to him the words of Lucretius,

> . . . he set his eager mind
> To burst through Nature's portals closely barred,
> And his keen mind prevailed, and far beyond
> The flaming ramparts of the world did pierce . . .

On the other hand, Linnæus was from first to last a natural philosopher; and if any comparison between these two great men may be made it would be in the recognition of their untiring devotion to work and their disinterested search for truth.

Even contemporary portraits of great men often fail to help us when painted by inferior artists, or when even good portraits have been badly restored. Often the words casually

written by their friends afford a greater help. Swedenborg was not much above medium height. The most striking feature in his face was the expression of his eyes—"smiling blue eyes" as one contemporary called them,—that retained their beauty even in his old age. Another writer states: "Being very old when I saw him, he was thin and pale; but still retained traces of beauty, and had something very pleasing in his physiognomy, and a dignity in his tall and erect stature." Of great gentleness of bearing, he avoided controversy: "If contradicted, he remained silent." He died in his 85th year unmarried; many pleasing stories are recorded of his love of children.

Linnæus speaks of himself as being "small, boisterous, hasty, and of ready wit." Something of his capacity for appreciating Swedenborg's character, is indicated by what we know of his relations with an ill-fated fellow-student of deeply philosophical mind,—Peter Artedi. Artedi,—not an Italian but a native of northern Sweden, the author of the well-known 'Ichthyologia' of 1738, but accidentally drowned in a canal before its publication,—was one of Linnæus's greatest friends during their student days at Uppsala, and later. It is in Linnæus's preface to that work, which he saw through the press after Artedi's untimely death in Holland, that we find a word-portrait of Artedi:

> I saw him before me, lofty of stature and spare of figure; his hair was long and his face reminded me of John Ray's; he struck me as humble-minded, not hasty in forming an opinion, but yet prompt, firm and withal mature,—a man of old-world honour and faith. It rejoiced me to remark that our talk turned at once upon stones, plants and animals, and I was much moved at having so many of his scientific observations confided to me without the least hesitation or reserve upon that very first occasion on which we met. (Lönnberg, 'Peter Artedi,' transl. by Harlock, 1905.)

By mutual agreement these two lived for years in friendly rivalry, always sharing their discoveries, but perhaps after keeping them as profound secrets for, at the most, three days only! When Linnæus started on his Lapland Journey, he made a Will leaving all his MSS. to Artedi, in case he should fail to return. With Linnæus as with Swedenborg kindness to children was a marked trait in his character; and several touching stories are recorded of his deep affection for his youngest daughter, Sophia.

All philosophers have not shown these kindly traits, however sublime their philosophy. Spinoza the excommunicated Jew of Amsterdam, was a man of austere life, who earned a mere pittance by polishing lenses, and who called himself glutton if he spent on food more than the equivalent of about

twopence per day. He is recorded to have had three relaxations: smoking his pipe, receiving his friends, and watching spiders fight until the tears ran down his cheeks with amusement. If there be Elysian Fields, I for one should prefer to avoid the corner occupied by Spinoza, and to seek by preference for Swedenborg and Linné.

The President having invited the Secretary of the Swedenborg Society, who was present, to speak, Mr. J. R. Presland said that he had followed with great interest the paper read by Mr. Savage. The Swedenborg Society would be glad to know that the letter it had the privilege of handing over to the Linnean Society would help to explain why a number of plants classified by Linnæus were not in the Herbarium itself. He thought that a similarity of interests between Linnæus and Swedenborg was evidenced in the fact that the latter took great delight in his garden at Stockholm and wrote most of his works in a summer-house in the middle of it. The summer-house is now preserved, furnished as Swedenborg left it, in the national park at Stockholm.

Mr. J. Ramsbottom said the point raised about specimens named by Linnæus not in the Linnean Herbarium was one of interest. It was only to be expected that Linnæus would name specimens for correspondents but it was probable that he would keep any of especial interest. The absence of type-specimens from the Linnean Herbarium was often due to the name being based on the description or drawing given by some previous author. Thus, for example, several of his types must be regarded as the plants in Plukenet's herbarium now in the Sloane Collection, some are based on the 'Hortus Cliffortianus,'—where occasionally no specimen was preserved for some reason or other, such as that the plant did not flower in the year when the book was in hurried preparation *.

The President expressed the thanks of the meeting.

Photographs of Dioscorea esculenta (Lour.) Burkill, taken by Dr. A. F. G. Kerr upon a limestone hill at Ban Keng, Krabin, Siam; also herbarium specimens and lantern-slides of the same plant. By Mr. I. H. Burkill.

Dioscorea esculenta, the Lesser Asiatic Yam, is a tuberous plant, cultivated rather widely in south-eastern Asia, and thence eastwards to Tahiti and westwards in Mascarenia, West Africa and the West Indies. It produces a bunch of tubers, which in some races underlie a mat of fierce thorns. In other races such thorns are not produced.

* *Menzelia aspera*. Hoc anno e seminibus enata nondum floruit.

It is clear that the thornless races have been evolved by man, who by guarding the plant in his patch of cultivation from destruction by wild pigs, has rendered the thorns superfluous and selected against them: and conversely it is among the thorny races that the wild type must be sought. But as some of the thorny races are to this day cultivated in the shifting uncertain cultivation of backward groups of men living against the forest, and persist on abandoned land, it is not a simple matter to determine the original home of the species.

Again ripe seeds have never been seen, and female flowers but rarely, so that the function of fruiting seems to be as much in abeyance as in the pine-apple and the sugar-cane.

Under these circumstances it is interesting to have before the meeting photographs showing the plant in a spot where shifting cultivation can scarcely have left it. Dr. Kerr in sending these photographs writes that upon the limestone hill at Bang Keng, Krabin, where they were taken, the plant was extremely common, making the ascent dangerous, for the black spines, sticking straight up from the ground, were not easy to see in the shade; and after having had the sole of his shoe pierced by one, he realised that the only mode of progressing with safety was from rock to rock.

It may be added that it was Dr. Kerr who found in the year 1924, at Saraburi in the same part of Siam, the only capsule which has yet been seen—a capsule with infertile seeds. The abundance at Krabin of a powerfully-armed race, such as may well be self-sufficient, and the near approach to fruiting at Saraburi suggest that Siam may be within the original home of this interesting plant.

The mat of thorns is not annually renewed, but grows by annual increments, for fresh roots arise year by year when the new tubers are formed, and having sloughed off the outer parts add their indurated cores to the armature.

Thorny roots are now known to occur in three sections of the genus *Dioscorea*, in *D. esculenta* of the section Combilium, in *D. prehensilis* of the section Enantiophyllum and in *D. piscatorum* of the section Paramecocarpa. The first seems to have had its origin in south-eastern Asia, the second is West African and the third is Malaysian. Dr. D. H. Scott described and figured the second some years ago. The third is almost unknown at present, but, as by the kindness of Mr. H. G. Keith, of the Forest Department of British North Borneo, the base of a plant has newly come to hand; it too was exhibited. The thorns in this are upon storage tubers.

Mr. H. N. Ridley remarked on the protection given to the Yam by its spines from wild swine, and instanced as a parallel the case of the spiny sago, which was the only species

which could be cultivated successfully in Borneo on account of the attacks of the wild pigs on the young shoots of the unarmed species.

Dr. A. B. Rendle asked if the spines on the roots were always rootlets, or if in densely spiny roots they were emergences. Mr. Burkill replied that they are always rootlets.

The President expressed the thanks of the meeting to Mr. Burkill, and to Dr. Kerr.

The new flora of Gore Cliff landslide. By Dr. T. A. Sprague and Mr. C. V. B. Marquand.

The progress during 1930 of the new vegetation on the Gore Cliff landslide, near Blackgang, Isle of Wight, was illustrated by a series of lantern-slides. In September 1929, 71 Vascular Plants had been observed on the landslide, and 80 additional species were seen during five visits made in April, May, September, October, and November, 1930. 32 of these additional species must, however, have been present during 1929, though not recorded, some being in sods brought down in the landslide, and others being represented by old plants etc. The corrected figures are therefore 103 species present in September 1929, and 48 additions during 1930. In 1930 the observed vascular flora of the "Reservation"—an area about 70×50 feet on the top of the Boulder Heap—was nearly trebled, being raised from 18 species to 53.

Interesting cases of dispersal by wind were afforded by *Buddleja Davidii* Franch. (*vide* Journ. Bot. 1930, p. 377) and *Artemisia Absinthium* L., of which the seeds and achenes respectively have been blown from a distance of ¼ mile in each case; and the mericarps of *Heracleum Sphondylium* L. appear to have been transported by wind from a distance of 200–250 yards from the parent plants. The primary agents of dispersal of fruits and seeds on the landslide seem to be as follows, in order of importance: wind (62 species), rain-wash (44), burs adhering to rabbits, cattle or man (15), simple contact (6), fleshy fruits eaten by birds (3). About 73 species have been introduced in the form of entire plants, tubers or rhizomes carried down by the landslide, either independently or in sods or larger pieces of turf, but 48 of these species have also been introduced in the form of fruits or seeds. Many species seem to have several means of dispersal. Most of those composing the new vegetation seem to have come from the area around the landslide, and 124 out of 151 have already been recorded from the neighbourhood.

Among the characteristic plants of the landslide are various species with stolons or rhizomes, e. g. *Equisetum maximum* Lam. (and *E. arvense* L. in smaller quantity), *Agrostis stolonifera* L., *Epilobium hirsutum* L., and *Mentha aquatica* L.

An interesting ecological modification of *Linum catharticum* L. was observed in bare patches of gault; this forms low compact much-branched very leafy plants. A similar form was seen in a deturfed area on a chalk down at Freshwater, Isle of Wight, where the plants of *L. catharticum* in the surrounding turf were of the usual erect, slender, little-branched, few-leaved type.

Browsing by rabbits exercises a considerable influence on the vegetation, the species most frequently eaten being *Equisetum maximum* Lam., several grasses and *Atriplex hastata* L.

A special study of the lower Cryptogamic vegetation of the landslide on four visits in 1930 at different times of the year between April and November resulted in raising the number of species of Bryophyta recorded, from two to seventeen (16 Mosses and 1 Hepatic); but of these, at least seven species of Mosses were found only in loose pieces of turf which had been brought down at the time of the original fall. A general spread of the more abundant species—*Funaria hygrometrica*, *Barbula cylindrica*, *B. unguiculata* on the malm, and *Tortula muralis* on the rocks—was observed during the year; while *Dicranella varia* has covered a considerable area on the Lower Boulder Slope near the "Triangle," and produced capsules in immense numbers. It is unlikely that there will be any very extensive additions to the Moss and Hepatic flora of the landslide until the *Sambucus* and other woody plants have grown up, and shade is produced by the covering of the exposed boulder heaps by copse. As soon as this occurs a large influx of Bryophyta may be expected from the very considerable flora noted in the adjoining woods. In November 1929 the gault pond was still filled with the dense growth of *Chara vulgaris* discovered in April; this has produced antheridia and oogonia in very large numbers, apparently holding its own with the *Spirogyra*, but it has not yet spread to other ponds on the landslide. This plant was not found in any of the neighbouring water which was surveyed in the autumn, so its source is doubtful, though the species has been observed in a number of localities on the Dorset coast.

Five species of Algæ were collected, including two species of *Spirogyra* in large quantity and a *Zygnema* in small quantity. In the upper pond two Diatoms (*Cymbella cymbiformis* and *Synedra ulna*) were abundant, while the former species was also found in large numbers in the streamlet on the western side of the landslip, where it was observed in September 1929. It may be worthy of note that the large pond at the bottom of the landslide is devoid of algal vegetation.

Perhaps the most noteworthy addition to the Cryptogamic Flora of the landslide is *Verrucaria sphinctrina* Nyl. (= *V. calciseda* DC.), the first appearance of a lichen on the newly exposed

surface of the calcareous sandstone rocks. This was discovered in October in several places of very small extent on the Lower Boulder Slope ; the perithecia were below normal size but the spores were well formed. The special interest in the discovery of this very inconspicuous species lies in the rapidity with which it has come to maturity. The algal cells forming the gonidial layer in the species of *Verrucaria* belong to the Protococcaceæ and would doubtless be introduced, as well as the spores, very soon after the fall which split up these blocks. On searching the vicinity in November 1930, it was found on the rocks east of the landslide, immediately south of the "Ancient Founder," whence it was probably introduced. *Cladonia fimbriata* forma *tubiformis*, common in the surrounding turf, has not yet been found on the landslide, possibly owing to the patches of turf being still of insufficient extent ; while *Xanthoria parietina* is restricted to the blocks of stone which formed part of the original road wall.

It was hardly to be expected that many Fungi would be found so early in the succession series, and apart from *Hypholoma velutinum* and *Peziza aurantia* only Uredineæ have been seen. Among the latter may be mentioned *Coleosporium Tussilaginis*, *Puccinia Senecionis* and the æcidial stage of *Puccinia Menthæ*.

With the exception of the Charophyte all these species have been seen also on the cliffs in the neighbourhood. Among conspicuous absentees, *Grimmia pulvinata* may be mentioned. No vestige of this little moss has yet been found on the landslide, though its characteristic cushions, fruiting abundantly, are to be seen on almost every stone on top of the walls by the road on each side of the landslide.

Mr. H. N. Ridley called attention to the number of species of plants brought by rainwash, which factor was not considered of importance by de Candolle or Guppy, and suggested that observations should be made on the birds visiting the pond now formed to see if they brought any seed on their feet.

Referring to Mr. Ridley's remarks Dr. D. H. Scott called attention to the abundance of *Isoëtes echinospora* in Littlesea, near Poole, Dorset, so far as he knew, the only place in the south of England where an aquatic *Isoëtes* occurred. The plant had only been observed in Littlesea for about five years, and its introduction by water-birds was suggested.

Mr. H. W. Pugsley, referring to Dr. Scott's remark, said that, as the Littlesea had been frequently explored botanically in the past, it was likely that the *Isoëtes echinospora* was a recent introduction.

A vote of thanks to the authors, expressed by the President, concluded the meeting.

19th February, 1931.

Sir Sidney F. Harmer, K.B.E., F.R.S., President, in the chair.

The Proceedings of the previous Meeting, held on Thursday, the 5th February, having been circulated, were taken as read and confirmed.

The President reported the deaths of our Foreign Members, Professor S. G. Navashin, Professor I. Urban, and Professor C. H. Ostenfeld; and pointed out that it was open to any Fellow to fill in forms of recommendation for new Foreign Members.

The President stated that the Fellows of the Society would be glad to know that, in consequence of the Resolution passed by the General Meeting on the 5th December, 1929, a letter had been received from the Secretary of State from the Colonies, enclosing a copy of Ceylon Sessional Paper XXXIII —1930, which dealt with the introduction of animals from strange countries, and laid down rules for the issue and regulation of acclimatization licences in a very satisfactory manner.

A list of names of those who had made gifts to the Library since the previous meeting was read and laid on the table.

The following Fellows signed the Obligation in the Book of the Charter and Bye-laws and were admitted:—John Joseph Sheldon and Charles Horton Bestow.

Certificates of recommendation of the following candidates for Fellowship were read:—For the second time in favour of Niranjan Mukerjee and David Guthrie Catcheside. For the first time, in favour of Alfred Samuel George Mardon, Leonard Charles Rudolph Messel, John Edward Senaratna, Eric Lomax Crossley, and Cyril Diver.

On the invitation of the President, Professor J. Stanley Gardiner informed the Society that he had just received news from Mr. E. B. Worthington, F.L.S., on the progress of his expedition to explore some of the lesser African lakes, especially Lake Rudolph. Primary difficulties have been overcome, and a steel motor life-boat is at work on Lake Rudolph: important results have already been obtained as to the affinities of the fauna and interesting observations on correlated fluctuations of salinity and population.

Mr. V. S. Summerhayes (Visitor) gave an account of his paper "The Angiospermic Flora of the Seychelles Archipelago" (communicated by Prof. J. Stanley Gardiner), which was followed by a paper entitled "The Flora of the Chagos Islands" by Dr. J. C. Willis and Professor J. Stanley Gardiner, of which Prof. Gardiner gave an account.

Mr. I. H. Burkill placed the inland (Mascarene) forest flora of the Seychelles, not as of Asiatic origin, but as part of an old Miocene flora now broken into three parts: one Mascarene; a second the rain forest flora of Ceylon; the third Malaysian. The Lemuridæ have a long association with it. *Nepenthes* in Mascarenia is explained by it, and so is *Melastoma*, etc. A history of dry climates excludes it from Africa.

Referring to Professor Gardiner's remarks on the Chagos Island flora he called attention to the length of geological time over which random shots have had here and there chances of success.

Mr. T. B. Blow asked with regard to what is probably the most interesting endemic tree in the Seychelles, *Lodoicea seychellarum* (the double coco-nut), in what quantity it still exists, and whether, in view of its occurrence in one island only of the group, Mr. Summerhayes regarded it as a disappearing species.

Dr. A. B. Rendle asked whether, in view of the spread of cultivation and the introduction of alien species there was indication of such extermination of the original flora as had happened in other oceanic islands with a peculiar and ancient flora. Further, would a comparison of Mr. Summerhayes's list with that published by Mr. J. G. Baker in 1877 indicate that endemic species had disappeared or were threatened with extermination?

Mr. E. G. Baker stated that in his father's flora 338 species were recorded for the Seychelles, and he congratulated Mr. Summerhayes on the advance in our knowledge that had been made.

The President having expressed the thanks of the meeting, the authors replied.

Mr. J. Ramsbottom exhibited two volumes of the 'Proceedings' of the Society of Amateur Botanists. These had been presented to the Hackney Microscopical and Natural History Society in 1880 and had afterwards been acquired by the late Sir George Watt: they were purchased recently by the Trustees of the British Museum, and are now in the Department of Botany.

The 'Proceedings' contain most of the papers read before

the Society in 1863 and 1864—all in manuscript except one. Extracts were given from the Presidential Address of 1863 which showed that the Society was started in December 1862 by the efforts of M. C. Cooke and five of his old students. The Society lapsed in 1865. The list of members given in the two volumes contains the names of several who, then mostly very young, later became prominent naturalists.

The Society of Amateur Botanists was referred to at a meeting of our Society on 2nd Dec., 1926; a full account of the proceedings was given in the President's address to the Quekett Microscopical Club this year.

The PRESIDENT moved a vote of thanks to Mr. Ramsbottom for this interesting exhibit, and his remarks thereon.

Mr. E. G. BAKER showed an album containing a collection of photographs of botanists who had been his father's contemporaries.

An expression of thanks to Mr. Baker concluded the meeting.

5TH MARCH, 1931.

Sir SIDNEY F. HARMER, K.B.E., F.R.S., President, in the chair.

The Proceedings of the previous Meeting, held on Thursday, the 19th February, having been circulated, were taken as read and confirmed.

A list of names of those who had made gifts to the Library since the previous meeting was read and laid on the table.

The following Fellows signed the Obligation in the Book of the Charter and Bye-laws and were admitted :—Arthur Erskine Ellis and Isabella Gordon.

Certificates of recommendation of the following candidates for Fellowship were read :—For the second time, in favour of Alfred Samuel George Mardon, Leonard Charles Rudolph Messel, John Edward Senaratna, Eric Lomax Crossley, and Cyril Diver. For the first time, in favour of Marjorie Alison Westbrook.

The following candidates, whose names were read for the third time, were balloted for and elected Fellows :—Prabhat

Chandra Sarbadhikari, Ph.D., Ben Dawes, Niranjan Mukerjee, and David Guthrie Catcheside, M.Sc.

Mr. H. E. Forrest opened a discussion, illustrated by maps and lantern-slides, on "The Relation of the Fauna and Flora of the British Isles to those of North America."

Heer has shown that out of 461 species of fossil plants in the Freshwater Molasse of Œningen, Switzerland, 232 are American. He and Unger accounted for this by supposing that the present basin of the Atlantic was occupied by land over which the Miocene flora could pass freely. That there was a land connection in the north is generally accepted. Mr. Forrest submitted that there was also a connection in temperate latitudes. In Miocene times the present great mountain-ranges had not risen. The whole of the land in the Northern Hemisphere was almost uniform in physical features and climate, and, as it was continuous from E. to W. through Asia, Europe, and the Atlantean Continent, to the West coast of North America, there was nothing to prevent any species ranging from Spain to Spitzbergen, or from China to Canada. Engler gives a long list of plants which range right across the Northern Hemisphere. The genus *Sequoia* is an instance, though now confined to California.

Amongst mammals the Arctic Hare (*Lepus timidus* L.) has a similar range in northern and temperate latitudes. But if we lump together all the multiple forms of white-footed mice comprised in Linnæus's *Mus sylvaticus* (probably the most numerous mammal in the world) we have a species which almost equals *Sequoia* in extent of range. A large number of freshwater plants occur in temperate latitudes of Europe and North America. These can hardly have reached their habitats by a northern land-bridge only. Their presence shows that the temperate zone of the Atlantean Continent was a plain with a system of freshwater lakes and streams intercommunicating.

Mr. Forrest showed maps suggesting the result of restoring the bed of the Atlantic to the level at which it probably stood in Miocene times. It formed a plain with a low range of hills running N. and S. down the centre: or either side of these hills were large lakes and marshy tracts the western lakes in direct communication with the Great Lakes of America.

In the Atlantean Plain would be the following freshwater plants:—*Potamogeton natans* and *pusillus*, *Myriophyllum spicatum*, *Lemna minor* and *trisulca*, *Alisma Plantago*, and *Lobelia Dortmanna*. These occur on some of the Atlantic

islands as well as on the mainland. Many ferns are common to Britain and America, including *Pteris aquilina*, *Asplenium Trichomanes* and *Ruta-muraria*, *Scolopendrium vulgare*, and *Osmunda regalis*. About 70 per cent. of mosses and fungi are common to Britain and America.

Amongst animals, especially insects and molluscs, examples are numerous. Great significance attaches to the distribution of species with a restricted range.

A freshwater sponge, *Heteromeyenia ryderi*, is found only along the eastern sea-board of N. America, and W. of Ireland and Scotland. Somewhat similar is the range of the orchid *Spiranthes Romanzowiana* (=*stricta*) and *Eriocaulon septangulare*. The Bony Pike (*Lepidosteus*) is fossil in the Isle of Wight, but living in the rivers of America. The mollusc *Nucula cobboldii*, fossil in the Isle of Wight, is living in Vancouver Island.

The European and American Beavers are identical, and many zoologists consider that the Brown Bear of Europe and the Grizzly Bear of America are two forms of the same species. The same applies to the Wolves, Foxes, and Otters of the two Continents.

Special interest attaches to the species of plants and animals classed by Dr. Scharff as Irish-Lusitanian; in particular to the "London Pride" (*Saxifraga umbrosa*). It grows wild only in the Iberian Peninsula and in Ireland. It could not possibly have travelled from one country to the other without leaving traces in France and Cornwall. It seems clear that Spain and Ireland were the easternmost limits of its range in Miocene times, and when the Atlantean Continent sank in late Pleistocene times these remained isolated. The region which sank is marked by the Continental Shelves E. and W. of the Atlantic. Outside these lines there was but little change of level—Europe and America remain *in statu quo*. The distribution of all the Irish-Lusitanian species can be explained in the same way.

Finally he suggested that certain fishes and crustaceans originated in the lakes and rivers of the Atlantean Continent. The Entomostraca *Mysis relicta* and *Limnocalanus macrurus* (=*grimaldii*) are abundant in most of the Great Lakes of America, and in certain British lakes, as well as in the Baltic (Gurney, Journ. Linn. Soc., Zool. xxxv, p. 236). In the same lakes various subspecies of the fishes belonging to the genera *Coregonus* and *Salvelinus* are abundant, and *Mysis* is said to be the staple food of the *Coregoni* in the American Great Lakes. Both *Coregonus* and *Salvelinus* are Salmonid fishes, and, in common with *Salmo*, the various forms grade into one another so imperceptibly that it is difficult to decide which are entitled to specific rank. As a family the Salmonidæ

are mainly Atlantean, and he suggested that they originated in the great freshwater lakes and rivers of the Atlantean Plain. In Pliocene times these would communicate with the Great Lakes of America on the west and the British lakes and Baltic on the east. Both fishes and crustaceans would have access to the waters on either side of the Atlantic which they now inhabit. A notable characteristic of all these creatures is that they inhabit fresh, brackish, or salt water indifferently. This characteristic is almost peculiar to them and the Sticklebacks (*Gasterosteus*), and if they originated as suggested, it is easy to understand how it was acquired. As the land gradually sank the salt water would enter the Atlantean Lakes and render them first brackish, and then—when entirely submerged—salt. Thus the inhabitants would become inured to water of varying salinity. Not being sea forms, however, they would disappear from the ocean eventually and be left as relict species in the waters which they now inhabit.

If such was the past history of the Salmon, this accounts for its migratory habits. Originally it probably spent the greater part of the year in the Atlantean Lakes, but ascended the rivers to spawn. When these lakes sank beneath the sea it continued to take the same course, and apparently, it does so still. The parr goes down to the sea weighing a few ounces and returns later a salmon of several pounds weight. So deeply implanted is the migratory instinct that the Salmon in certain American Lakes which do not communicate with the sea, ascend the tributaries to spawn and then return to the lake, resorting to the latter in lieu of the sea.

The Eel probably originated in the Atlantean lakes and rivers, but contrary to the Salmon, it resided mainly in the rivers and spawned in the lakes. Nowadays it spends three to five years in inland waters (American and European), then descends to the sea, spawns in the depths of the Atlantic (its original habitat), and dies.

The above are only a few of the problems on which the former existence of an Atlantean Continent sheds a new light.

There is a great body of evidence that in Pleistocene times the northern part of the Atlantean Continent (including Greenland, Iceland, the Faroes, etc.), stood at a much higher level: the "Atlantean Alps" formed a vast snowfield, and this, coupled with the absence of the Atlantic Ocean with its Gulf Stream, was in Mr. Forrest's opinion the cause of the Great Ice Age. This snowfield was the source from which emanated the Ice-Sheet which glaciated a great part of both Europe and America.

Dr. C. Tate Regan stated that the distribution of certain species is used by Mr. Forrest to support the theory of a continent

connecting Europe and America across the North Atlantic, but the examples he has given are just as well explained by the supposition that the northern continents have occupied nearly the same areas since the Eocene, except for connections between Asia and America across the Bering Sea, and possibly between Europe and America via Iceland. The freshwater fishes of North America are mostly quite different from those of Europe; none of the characteristic North American families, Amiuridæ, Castostomidæ, Centrarchidæ, etc., is represented in Europe. The only European species found in North America are northern types that range through Siberia, such as the Pike. The Salmonids (Char, Whitefish), said by Mr. Forrest to have come from the Atlantic continent, are not true freshwater fishes. Char (*Salvelinus*) are marine fishes of the Arctic Ocean that run up rivers to breed, and form colonies in lakes; those of the lakes of Ireland, Britain, etc. may have entered them in Glacial times, when our seas were colder, and the limit of char in the sea was farther south. The history of the Whitefish (*Coregonus*) is similar. If in late Tertiary times the North Atlantic had been filled with a continent, with a coast-line straight across from Florida to Morocco, one would expect to find nearly the same marine fauna on opposite sides of the Atlantic. But the fishes of the coast of Tropical America (Carolina to Brazil) are quite different from those of West Africa, many of them belonging to endemic genera. It is only the northern species (Cod, Herring, etc.), found also in Iceland waters, that are common to America and Europe.

Dr. A. B. Rendle did not consider the existence of a North Atlantic continent necessary to explain the relationship between the floras of the British Isles and North America. Existing land-areas north of the Atlantic represented an adequate connection between Europe and America in view of the more favourable conditions known to have prevailed formerly in Greenland. Moreover, the existence of the Atlantean Continent suggested a greater similarity between the floras of South-West Europe and the Mediterranean area on the one hand and Eastern North America on the other than was borne out by facts. The South-West or Lusitanian element in the European flora finds a more satisfactory explanation as a European not as an Atlantean outlier.

Some of the species common to Europe and North America adduced as evidence by Mr. Forrest, such as *Pteris aquilina* and *Potamogeton natans*, have a very wide distribution, and have no bearing on the case. The distribution of *Eriocaulon septangulare* is remarkable, but it seems unnecessary to invoke an Atlantean continent to explain it.

He would remark on the similarity, with slight differences in the species, which impressed the British botanist visiting Canada and the North-Eastern States, and would stress the importance of a personal study of the North-East American flora by an expert British botanist and *vice versa*. Prof. Fernald has made an intensive study of the botany of the N.E. corner of America, and on a brief visit to Scotland last August made some interesting additions to our knowledge of the alpine flora of Scotland, including discovery of a species with which he was familiar in Newfoundland, but which was new to the British flora.

Prof. J. W. Gregory (Visitor) was reminded by Mr. Forrest's North Atlantean Icecap of the once assumed North Polar Icecap. If the glaciation of the British Isles was by ice from a North Atlantic Continent some of its rocks should be found in the British glacial drift. In the absence of such material the issue depends on the interpretation of the interesting cases of distribution to which Mr. Forrest had called their attention. He had attended to hear the views of the biologists on this evidence.

Mr. J. Ramsbottom said that he would not have ventured to take part in the discussion but for the fact that Mr. Forrest had seemed to lay stress on fungi in his abstract—" five-sixths of American fungi are also British." This statement was somewhat startling to a mycologist, but as it was based on an account for which he himself was partly responsible he should explain it. While attending the International Botanical Congress at Ithaca, in 1926, Mr. Carleton Rea and himself listed the species of larger fungi which they came across either in company or on their respective journeys. This list contained a high percentage of species which were known in this country. Microfungi were not considered. Incidentally he would support Dr. Rendle's remarks about the comparison in the field of the floras of North America and the British Isles: many agarics were obviously our species, others were puzzling, as they appeared off type, and others, as was to be expected, were wholly different; only by field work could these difficult forms be sorted out; two British species not recorded for America had been picked up within a minute or two of beginning serious collecting.

The figures quoted by Mr. Forrest refer to the larger fungi gathered during a month or so in eastern United States. If the whole of America was considered the percentage of species of agarics found also in Great Britain would be very much smaller, and if microfungi were considered as well the proportion would be greatly lowered. Only with the aquatic Saprolegniacæ do we find anything like five-sixths in common.

Restricting discussion to temperate parts of America, we have few parasitic fungi on native plants which can be used for comparison, for most of them are confined to definite host plants and so are present only when these occur.

It is startling to find "British" toadstools among trees and other plants which are quite different from ours, but this holds also for regions other than America. In South Africa he had found that practically all the agarics were also British. Similarly, careful drawings showed that there was a high percentage of these fungi common to temperate regions. Dispersal of a microscopic spore was a different matter from seed dispersal, and it seemed as if none of the main factors mentioned by Mr. Forrest influenced fungi, and at present it was unsafe to use the facts of distribution of these organisms to attempt to solve problems such as those of lost continents.

Dr. O. Stapf observed that he could not adduce any evidence in favour of Mr. Forrest's theory of land connection across the Atlantic so far south. As far as the distribution of the so-called "Lusitanian" element was concerned, this certainly does not help, as there was nothing on the American side to connect it with. The case of *Saxifraga Geum* in Newfoundland which was recently reported, still awaits confirmation of the nativeness of the species in that country. The simultaneous occurrence of so many species in Europe and in North America is probably very largely attributed to a more northern land connection in Tertiary times, such as is very generally admitted. A certain percentage, however, may be due to simultaneous northward radiation in both hemispheres from an old common area in the south, *e. g.*, *Eriocaulon septangulare*, *Brasenia Schreberi*, the latter now extinct in Europe. There is evidence of an extension of the "Lusitanian" element to Norway along a coast-line which connected Ireland and Scotland with Norway across what is now the North Sea. Along the same line northern elements spread southwards and they have left relic stations as far south as Ireland, where they mingle with "Lusitanians" in Clare Island, whose cliffs harbour *Silene acaulis* and *Saxifraga hypnoides* in intimate contact. This coast-line is the westernmost extension of land in this part of the Atlantic which we can safely postulate. Generally speaking, it is eminently desirable in dealing with problems like Mr. Forrest's to consider the species not only with regard to their special area, but also to those of their nearer and wider allies.

Mr. B. P. Uvarov (Visitor) drew attention to the volume "Contribution a l'étude du peuplement des Iles Britanniques," containing articles by eleven different authors who discuss the composition and origin of the respective sections of British fauna and flora. As a whole the volume contains a large

amount of evidence in support of the ideas expressed by Dr. Scharff in his well-known works on the British fauna.

In studying the fauna of a country from a zoogeographical point of view, it is necessary to apply ecological methods, that is, to consider the ecological requirements of each species and of its relatives. Orthopterous insects are particularly suitable for studies of this kind because of the very small number of British species, and the good knowledge of the ecology of Orthoptera generally.

Three zoogeographical groups may be distinguished amongst British Orthoptera. The largest consists of species distributed across Siberia and Northern and Middle Europe. This group originated in the Angara continent of geologists, situated in the Eastern Siberia and Mongolia, and members of this fauna reached British Isles when a westward migration of steppe and tundra animals took place. Amongst members of the Angara fauna there are some which occur in N. America as well, but they spread to America *via* N.E. Siberia. The second group consists of elements which Scharff called Lusitanian, but which should be more properly called Atlantic, as the present distribution of the groups to which they belong points to their having originated in the continent of Atlantis. This was, however, not the Atlantean continent of Mr. Forrest, but a dry rocky land situated at the latitude of the Mediterranean Sea and the Canary Islands. The third group is composed of insects belonging to families and genera now widely spread in the subtropics and tropics, and they are obvious relics of an age when the British Isles, together with the most of the Northern Hemisphere, enjoyed a mild subtropical climate.

In all three groups of British Orthoptera there are elements indicating a relationship between the faunas of Europe and America, but the relationship can in all cases be explained without accepting the idea of the Atlantean continent suggested by Mr. Forrest.

Mr. A. J. Wilmott emphasised the point made by Dr. Stapf that with the possible exception of *Saxifraga Geum* no species of the "Lusitanian" element of the British flora occurred in North America, as we might expect if Mr. Forrest's theory were correct. These Lusitanian species must be relics in Ireland, since there has been no connection southwards since the glaciation—the immediately preglacial beach lies about ten feet above the present beach along both sides of the English Channel and in southern Ireland. Moreover, these species are not particularly "cold-shy"; they ascend to considerable elevations in Ireland. *Saxifraga Geum* and *S. umbrosa*, brought to a London garden from Kerry in 1926, survived the heavy snows and hard frosts of the succeeding

winters, while Pyrenean *S. umbrosa* died: presumably the Irish plants are the hardiest survivors of the preglacial stocks. These species are "Atlantic," but not necessarily Atlantean. The wide distribution of water-plants is common knowledge. According to Professor Moss the British species which occurred in South Africa were mostly water-plants; presumably they are carried by water-birds.

It is a fact that many flowering plants are common to Europe and North America, though the number is being steadily diminished by critical study. There are a number confined to Europe and eastern North America, and Dr. Fernald has found several in America confined to the unglaciated parts of Newfoundland and the mouth of the St. Lawrence. But there are many species with limited distribution to-day, which formerly had a wide area of dispersal, as either the widely separated present areas or palæontogical evidence shows.

It may therefore be unsafe to assume that these restricted species were not previously more widespread, like others that range from Europe across Siberia and the Bering Straits into America. There are species to-day which are known only in the eastern United States and Japan, sometimes identical, sometimes two varieties of the same species, sometimes the only two species of a genus. Sometimes a genus contains three or four species in the eastern States, Japan, and China, showing that formerly the flora of the eastern States was connected with that of eastern Asia. It may therefore be *possible* that a species occurring only in Europe and the eastern States was originally connected across Asia and not across an Atlantis, and one should hesitate before drawing too definite inferences from present day distributions alone. As Dr. Stapf had insisted, critical study of the whole group of allied species and their distributions is necessary. A proper analysis of the whole flora may give indications of the history of its development.

Dr. G. P. Bidder pointed out that the distribution of the freshwater sponge *Heteromeyenia ryderi* in "W. Ireland and E. North America" given by Mr. Forrest (Address, p. 17) is taken, through Scharff *, from Hanitsch's pioneer list of Irish Freshwater Sponges (1895 β). The later extensive survey, on which Miss Jane Stephens based her admirable account (1920), showed that this is one of the commonest sponges in Ireland, but restricted to non-calcareous districts, densely populating four isolated areas in the W., S., E., and N. of Ireland and occurring in the Island of Mull.

* Scharff, R. F., "On the Evidence of a former Land-bridge between Northern Europe and North America." Proc. Roy. Irish Acad., Sect. B, xxviii, 1909.

Miss Stephens gives the opinion that, though not limited to W. Ireland, the distribution of *H. ryderi* supports Scharff's theory of a land-bridge to America from Ireland. But she does not discuss the distribution of *H. repens*, which occurs in America over approximately the same area as *H. ryderi*, and has otherwise been recorded only from Galicia (Wierzejski, 1892, *fide* Weltner 1895 *a*, p. 128).

The PRESIDENT conveyed the thanks of the Society to Mr. Forrest.

Mr. FORREST, in reply, said that it seemed to him unlikely that freshwater plants such as *Lemna minor*, which does not range far north, could reach Madeira and the Azores via a land-bridge in the north. Wegener's theory was negatived by the formation of Bermuda : this coral island rose pillar-like from a depth of over 2000 fathoms, a fact which proved that the subsidence of this area had been so gradual that the polyps were able to keep pace with it. If the whole area had subsided 2000 fathoms, the converse must be true—that it formerly stood 12,000 feet higher. This would produce land—an Atlantean Continent—in place of the Atlantic Ocean.

19TH MARCH, 1931.

Sir SIDNEY F. HARMER, K.B.E., F.R.S., President, in the Chair.

The Proceedings of the previous Meeting, held on Thursday, the 5th March, having been circulated, were taken as read and confirmed.

A list of names of those who had made gifts to the Library since the previous meeting was read and laid on the table.

The following Fellow signed the Obligation in the Book of the Charter and Bye-laws and was admitted :—Niranjan Mukerjee.

A certificate of recommendation of the following candidate for Fellowship was read :—For the second time, in favour of Marjorie Alison Westbrook.

Photosynthesis and Solution in Formation of Coral Reefs.

By J. Stanley Gardiner, F.R.S.

The old writers on coral reefs, such as Chamisso, Darwin, Dana, Semper, L. and A. Agassiz, Murray, and perhaps Wharton, can scarcely be labelled as belonging to any particular science in a modern sense. In contrast, the investigator of the "Coral Reef Problem" to-day is usually either a geologist or a zoologist, for the botanist has not up to the present understood that he may claim an equal partnership. Unfortunately the geologist is usually profoundly ignorant of biology, although well acquainted perhaps with the shapes of organisms and the possibilities of earth-movements. The biologist, on the other hand, has views as to the disappearance of Gondwanaland, but his writings indicate his incredulity as to any suggested existence of similar earth fluctuations to-day. The mobile crust of the earth allows of movements in the earth's surface, but these are more often supposed to be activated by chemical processes in its inner material than by alterations in the land and sea above. In addition there are the physical and chemical reactions of the ocean's water, and the possibilities of these, little understood even to-day, are almost unconsidered.

I claim that there are two primarily biological forces found together on all coral reefs, and assisting to shape them. Photosynthesis gives an extraordinary efficiency to the reef-building organisms, and, as a result, causes an incredible rapidity of formation of limestone and thus of reef-growth. This is countered by solution of limestone by boring organisms, superficially appearing small in itself, but actually a main factor in that fight between death and life that is visible on every reef.

The photosynthetic method of carbon feeding in most plants, depending on their contained chlorophyll, is too well known to require further reference. There are many halophilous phanerogams, which hold the sand of surface reefs together, and thus add materially to their permanency. Bare rock-surfaces are covered by about forty species of low growing, mostly blue-green, algæ that prevent their destruction. A few seaweeds such as *Halimeda*, with precipitated lime in their fronds, assist to form deposits in the sea and may even be the chief material filling up parts of lagoons. But the main reef builders are about twelve species of five genera of Lithothamnioneæ, which possess dense skeletons of lime in the composition of which magnesia up to about 20 per cent. may play a part. Only a thick surface film is living, the light being unable to penetrate deeply through cells which are ever depositing lime in their walls. The encrusting forms thicken slowly, but push out their edges rapidly, over 20 mm.

Issued May 20th.]

being recorded in four weeks. *Goniolithon* in finely branching growths affects the surfaces of barrier and atoll reefs behind the actual edge zone, which is covered almost entirely by incrusting *Lithophyllum*, pushing up into branching but rounded masses. This genus is abundant in places down to 10 fms. on the seaward slopes, but gradually *Lithothamnion* becomes the dominant plant builder, its deeper species, small branched but rather delicate detached growths, often completely covering the whole surface. All genera belong to the encircling reef, atoll or barrier, not occurring on lagoon shoals or floor.

The sedentary animal builders are all cœlenterates. Of first importance are corals (Madreporaria), the builders here all massive or branching forms, each a single animal, but with vast numbers of feeding and breeding organs in its polyps. Then there are the stinging hydroid (*Millepora*) and the blue coral (*Heliopora*) which grow generally to form massive upstanding plates, the animal matter a surface film perpetually depositing its lime below. The last is an Alcyonarian, and there must be added a series of forms from this group, the organ-pipe coral (*Tubipora*) and the soft corals (*Sarcophytum*, *Sclerophytum*, *Lobophytum*, and *Xenia*), all of which form their lime in spicules, which may play a considerable part in sand formation.

In animals feeding is not so simple as in plants and consists of three processes concerned with oxygen, carbon, and nitrogen. Oxygen is the hydrogen-acceptor in respiration in both animals and plants. Carbon must be supplied as carbohydrates, produced by plants. The greater motility of animals, considerable even in sedentary forms, implies the necessity of a more bountiful supply of oxygen and the casting out of more carbonic acid and of nitrogenous waste products. The last has been met by the evolution of nephridial kidneys in higher animals, but the excretion is probably a function of all free surfaces in sedentary cœlenterates, calling for a special water circulation to remove poisonous materials.

These special difficulties in respect to the nutrition of coral-building sedentary animals in tropical waters has been met by the " taming " of unicellular green flagellates (*zooxanthellæ*) by the polyps—or the polyps being adopted by such plants—housing them as symbionts in their " endoderm " cells. In 1896, at Rotuma, I found corals from which oxygen was being given off, and subsequent observations in the Maldives and on the Sladen Expedition convinced me of the importance of this phenomenon, of which Dr. Yonge has recently given experimental proof. Such oxygen production on the part of these symbiotic algæ implies the formation of much carbo-

hydrate material, and in the absence of specially rapid fission in the algæ we may infer the passage of much of this to the polyps. Thus we may suppose the alga to be largely responsible both for the oxygen and for the carbohydrates required by the polyps, but it is possible that the alga is of even greater importance as a scavenger which thrives on the waste products of its animal. The utilization of the animal's carbon dioxide is probably of small importance, for its disposal is easy, and the polyp during the daylight, in which the alga's chlorophyll is alone functional, is largely quiescent. The utilization of the animal's nitrogenous waste probably provides the alga with its sole available source of nitrogen, the other required salts existing as such in the polyp's protoplasm. In this connection the absence of other non-infected kinds of cœlenterates and of polyzoa from the shallower waters of coral reefs is significant.

The depth from which our coral reefs of to-day grow is that at which photosynthesis is active. This is about 60 fathoms for plants and 45 fms. for the plant-animals as maxima. These depths fluctuate in accordance with the turbidity of the water, which increases in the proximity of land masses and decreases in the Pacific and Indian Oceans from east to west, probably in correlation with the eastern influx of polar waters. This turbidity is largely due to unicellular algæ, and a second factor is introduced by their utilization of any carbon dioxide in the water to the detriment of reef-building organisms. That plants would be affected is clear, and it is hard to believe that polyps could provide sufficient carbon dioxide both for their symbionts and for their own lime skeletons. On reefs the presumption is that the extra requirements of the polyps are met by their algæ breaking up the bicarbonates of the lime-saturated sea-water. Evidence of this is found in that amorphous lime is sometimes precipitated on the tissues of the free parts of the polyps. Where there are active water movements, it is presumably swept away in the consequently heavy mucous lubrication of the polyp's surfaces, but in the deeper lagoons and in other areas of still water the lime clings to the polyps and kills them. This, up to the present, is the only suggestion explanatory of the fact that lagoons have singularly little coral and algal growth on their floors, and that upgrowing shoals do not occur in lagoons save in the proximity of passages into them.

The rapidity of growth of coral-building organisms is well known, and independent estimates agree that a reef might grow up from 14 fms. to the surface in 1000 years, but the speed of its deposition is not material to our hypothesis. The horizontal outgrowth of reefs is considerable, depending on the extension of their foundations by their own talus

material. On the earth's crust below the reef there is a weight of 2½ times that of the sea-water replaced by the coral reef, an addition of 150 per cent. Can these—or the analogous weight alterations that happened in the formation of many geological strata—be reacting on the earth's crust to produce subsidences? We can give no reply, for we have few data as to the strength of the earth's crust and as to the detailed topography of the deeper oceanic slopes off coral reefs, but no one with experience of the Pacific Ocean can doubt the activity of crustal movements even to-day. This question *must be tested*, and it is not beyond the scope of the geophysicist, who should be able to tell us at what depths below atolls limestone is underlaid by igneous and other rocks.

Solution of limestones is partially a physico-chemical matter, and this side has been sufficiently dealt with in respect to the coral-reef problem by many workers. Lagoons are supposed to be formed by solution and by the removal of mud in suspension, generally organisms only mentioned as by their decay providing carbonic acid gas to help the solution. The mud is accepted as an expected formation wherever land or reefs occur, few observations on its production having been made. Yet this is of great importance, since it entails the study of the decay and grinding up of coral rock in which nearly all the facts are biological, current action not being considerable on reefs that are clothed by living organisms. Every mass of limestone is visibly bored into by organisms, viz., molluscs, worms, sipunculids, sea-urchins, and certain barnacles. Some of these grind their tunnels, while others dissolve them out, most using both methods. As a result of the examination of many specimens, I reach the conclusion that it is seldom that more than 40 per cent. of the mass is thus removed by the above animals. I get larger figures from sponges, but on the whole they are not as important boring organisms in tropical as in temperate seas. But on coral reefs I find that all limestones (massive rocks, corals, nullipores, stones, and pebbles) are penetrated by a network of the finest threads, which are clearly algal in nature. These are the chief boring organisms of coral reefs and the primary cause of the reduction of limestone to pebble, sand, and mud, a whole sequence of organisms aiding them. They bore solely by solution, and, while molluscs probably bored primarily for protection, many other forms may well have been seeking for the nutriment these algæ provide. In living corals the boring hyphæ advance in the corallum so close to the polyps that we can even imagine that the latter is thrown down to fend them off. In nullipores they enter the skeleton less easily, and their action is slower and less marked. I have tried by various means to estimate their actions, but the error factor is too great to make any

figures of real value, partially because I cannot find one part of the same coral skeleton bored and another unbored. In undisintegrated coral skeletons, of which the polyps were living, our figures vary from 10 to 60 per cent. of the coral dissolved away, while in dead corals of the same species the figures are 40 to 83 per cent. The last figure is exceptional, because usually the coral breaks up into pebbles long before it becomes so reduced, but the boring algæ still live in these until smothered by mud or consumed by sand-feeding organisms. In any case I submit that the solution of limestone by boring algæ is a primary feature in shaping coral reefs and one deserving of the closest investigation by modern methods applied upon the reefs themselves. In particular, I am desirous of ascertaining whether the importance of these forms, observed by me on Maldivan material, is applicable generally to the formation of all coral reefs.

Mr. I. H. Burkill, referring to the outer rim of a coral reef as the place where the reef-algæ find the optimum conditions for growth, recalled Mr. H. D. La Touche's observations (Mem. Geol. Survey Ind. xxxix, p. 327) on the maintenance of the sharp edges of the falls of the Myit-nge River in the Shan Hills, Burma, by incrustation due apparently to algæ.

Professor R. R. Gates said that he had been inclined to leave the problems of coral-atoll building to the zoologists and geologists, but that evidently the botanists were equally concerned. Professor Stanley Gardiner's presentation of these problems had been of extreme interest to him, both as regards the part taken in reef-building by Lithothamnia, and the symbiotic condition and physiological effects of the zooxanthellæ in the coral polyps. He asked when the infection of the planula larvæ by the green cells took place.

Prof. E. W. MacBride said that he had listened with great interest to the paper of Prof. Gardiner on coral reefs. Prof. Gardiner had assumed that when coral grew on a submerged bank its increasing weight tended to depress the bank, a depression which was compensated by the continued growth of the coral. This view was in full accordance with recent geological theory. The enormous thickness of coarse sediments deposited in some ancient estuaries which make up great portions of our geological "formations" has long attracted attention, and has been usually accounted for by the theory that the deposition of these sediments corresponded to a contemporaneous sinking of the land. It was now realised that any general sinking of the land would have produced a marine "transgression" which would have blotted out the estuary and the river flowing into it. The subsidence, it was now believed, was merely local and was produced

by the weight of the sediments themselves. There were certain difficulties, however, connected with Prof. Gardiner's theory with which Prof. MacBride would like him to deal. In the Western Pacific Prof. Wood-Jones had shown that there was strong reason to believe that coral reefs had recently been elevated. Again, whilst Prof. Gardiner had assumed that the coral lagoon owed its origin to the death and decay of the central corals in a mass which originally grew all over a submerged bank, Prof. Wood-Jones put forward the more plausible theory that the first rudiment of an atoll was the emergence of a single dome of growing coral at the surface. When this dome had come within reach of the waves portions of it were broken off on the two sides and deposited in two lines of talus stretching like arms in the direction of the prevalent winds and currents. On these banks fresh coral grew, and so eventually a ring-like form was built up. Prof. MacBride also pointed out that Prof. Gardiner's assumption of the all-importance of the symbiotic algæ to the life of the coral was not altogether in accordance with Dr. Yonge's recent researches on the physiology of the corals of the Barrier Reef.

Mr. A. G. Lowndes raised a point about subsidence supposed to be due to the weight of large masses of coral, and suggested that if the weight were sufficient to cause subsidence to any great extent it should also have the effect of recrystallizing the amorphous calcium carbonate.

Dr. G. P. Bidder mentioned that Van Trigt found that the green algæ in the tissues of freshwater sponges are untouched by the sponge in times of plenty, but digested in times of dearth. This appears from Yonge's observations to be untrue as to the algæ in corals; but even if they are never digested is it not possible that the sponge derives carbohydrate nourishment from the continuous secretion on their cell-walls? As to the precipitation of carbonate of lime, does not one theory suggest that this may be produced by animals with ammoniacal excretion, the sulphate of lime being replaced by carbonate of lime and sulphate of ammonia?

Dr. W. T. Calman expressed his appreciation of Professor Gardiner's very lucid exposition of the many problems suggested by coral reefs. He called attention to the fact that Dr. C. M. Yonge, as a result of his extensive physiological investigations carried out in the course of the Barrier Reef Expedition, had arrived at the very definite conclusion that the coral polyps derived no food material whatever from their commensal algæ, although the latter were probably of great importance in relation to respiration and excretion.

The President, after expressing the thanks of the meeting, referred to the fact that Professor Gardiner had for many years maintained the importance of plants in the ecology

of coral reefs. The slides shown at this meeting were very convincing in demonstrating the protection afforded by calcareous algæ to the outer edge of the reef exposed to the full force of the sea. Professor Gardiner had made interesting suggestions with regard to the relation of symbiotic algæ to the metabolism of coral polypes, as well as to the part probably played by Thallophytes in the breaking up of dead coral and in affording nutriment to fishes and other animals which assist in this process. He was to be congratulated on the special interest of his communication, which represented the results of study devoted during many years to the problems arising out of his well-known investigations in the Indian Ocean.

Entomological Expedition to Abyssinia, 1926–27. Coleoptera, Staphylinidæ: Systematic Report and Introduction, with biogeographical and ecological remarks. By Dr. Max Bernhauer and Dr. Hugh Scott.

Dr. Scott said that, apart from the purely aquatic fauna discussed in the series of reports on Abyssinian freshwater problems now appearing * under Mr. Omer-Cooper's direction, four reports and several shorter notes on insects have already been published, covering the Collembola, Thysanoptera, Embioptera and true Neuroptera, Trichoptera and Ephemeroptera, and the distribution of mosquitoes. The Staphylinidæ are the subject of the first report on terrestrial Coleoptera, of which about 9000 specimens, mostly minute and obscure and representing many families, were collected.

Dr. Bernhauer enumerates 123 species, only 11 of which had been recorded from Abyssinia before, while 56 are described as new to science. Many other species have been previously described from Abyssinia by Bernhauer and other writers, but the family is an enormous one, and probably a few hundreds at most are known out of a fanna that, in a country so vast and varied as Abyssinia, may amount to several thousand species. The collection under review was made only in the plateaux and mountains of central Abyssinia at high altitudes.

After translating and arranging Dr. Bernhauer's descriptions, Dr. Scott analysed the material from a zoogeographica) standpoint. Although Staphylinidæ are not the best subjects for such analysis, owing to their great mobility and the wide distribution of many species, certain conclusions have been embodied in a short Introduction. All the genera represented are very wide-ranging, excepting a few small African genera. The species are mainly African in their affinities (this applies to, roughly, two-thirds of the previously-known species and a certain proportion of the new species), and chiefly East or South African. But there is a small Northern element,

* In the ' Proceedings of the Zoological Society.'

consisting of a few Palæarctic species or related forms. There is no Oriental element, unless it is indicated by a very few species common to Africa and either Madagascar, the Mascarene islands, or the Seychelles.

Probably many African species are widely distributed over the higher parts of the Eastern half of the continent from Abyssinia to South Africa, but they may not occur in intervening lower areas. The Northern element might have been larger had the collectors been able to visit districts farther north.

We may compare the results of the investigation of the Collembola (spring-tails) *. Only fifteen species (of which this expedition obtained twelve) are known from the Abyssinian highlands—probably 5–10 per cent. of the total Collembolan fauna. They include no Palæarctic element, and thirteen of them are apparently endemic. Their affinities are with the other mountainous parts of Eastern Asia, but a connection is also established with the hitherto isolated Collembolan fauna of the Seychelles. This is remarkable, since in most groups of insects the Seychelles fauna shows Oriental rather than African affinities.

Again, among the twenty-seven species of aquatic Hemiptera collected, two have clear Palæarctic affinities, while the remainder are Ethiopian. The two former were found, respectively, in streams flowing into a tributary of the Blue Nile and in a pond very little south of the watershed, so possibly these northern insects have worked their way southwards up the Blue Nile to the Abyssinian highlands †.

The biogeography of these groups of insects is bound up with the problem of the Abyssinian fauna as a whole. The latter is African, but includes some Palæarctic and Oriental elements. For the Palæarctic, witness the Walia ibex (*Capra walie*), known only from the high mountains of Simen ; the Cornish chough (*Pyrrhocorax pyrrhocorax*), found in some of the highest mountains and (outside Abyssinia) not nearer than Syria and North-West Africa ; and the loach (*Nemachilus abyssinicus*), inhabiting the waters of Lake Tana, sole African representative of a European-Asiatic family. An Oriental element occurs in the shape of a handsome fritillary, *Argynnis hyperbius*, the range of which includes the whole Oriental Region from Japan and New Guinea right across to India and Ceylon (with a detached portion half-way down the east side of Australia), while the only part of Africa in which it occurs is Abyssinia. Are these cases simply isolated relics, or will there be found in the small invertebrate

* Handschin, Trans. Ent. Soc. lxxvii, pp. 15–28, 1929.
† G. E. Hutchinson, Proc. Zool. Soc. pp. 437–466, 1930.

fauna, when it is worked out group by group, a certain proportion of Northern and Oriental species ? This is a question which the results of the expedition may help to answer. In this connection, reference may be made to the relicts of a former Southern extension of the Mediterranean fauna now being discovered at high altitudes in the Hoggar Massif, isolated in the Sahara, more than 2000 miles north-west of Abyssinia *, and 700 to 800 miles south of the Atlas Mountains.

Staphylinidæ were collected in many kinds of habitat. Dr. Scott's captures were mostly made in dense forests between 8000 and 10,000 feet, and on treeless heath-land above 10,000 feet, while Mr. Omer-Cooper's were mainly from lake-shores and margins of rivers. Special attention was paid to dead stems of tree-Euphorbias (*Euphorbia abyssinica*), to compare the beetles found in them with those of the Euphorbias of the Canaries and other Atlantic islands and of Morocco (the extensive coleopterous fauna exclusively attached to the arborescent and shrubby Euphorbias of the islands was brought to light largely by T. Vernon Wollaston in the last century, and quite recently a comparative investigation has been made of the euphorbicolous Coleoptera of Southern Morocco). Twelve species of Staphylinidæ were obtained (with many other organisms, not yet worked out) from the Abyssinian tree-Euphorbias and, while most are accidental visitors found in other types of habitat as well, two new species of *Atheta* appear to be members of a special euphorbicolous fauna. *Atheta* is one of the few genera of Staphylinidæ figuring among the euphorbicolous Coleoptera of Southern Morocco, though it is there represented by a different subgenus.

Many beetles, comprising an undescribed species of *Cryptophagus* and four species of Staphylinidæ, were found under the bark of dead stems of the great tree-lobelias (*Lobelia Rhynchopetalum*) which grow at 12,000 feet and upwards. The four Staphylinidæ include two other new species of *Atheta*, probably belonging to a faunistic association special to the giant Lobelias of the African mountains, and not hitherto investigated.

Dr. W. T. Calman having commented on the clearness and interest of Dr. Scott's exposition of the paper, the President expressed a vote of thanks to Dr. Scott.

* See ' Entomologist's Monthly Magazine,' lxvi, pp. 5–7, 1930.

16th April, 1931.

Sir Sidney F. Harmer, K.B.E., F.R.S., President, in the Chair.

The Proceedings of the previous Meeting, held on Thursday, the 19th March, having been circulated, were taken as read and confirmed.

The President referred to the loss to the Society by the death of Professor W. Carmichael McIntosh, the Father of the Society, who was elected a Fellow on the 5th March, 1863.

A list of names of those who had made gifts to the Library since the previous meeting was read and laid on the table.

Certificates of recommendation of the following candidates for Fellowship were read :—For the first time, in favour of Joseph Davenport Snowden, Clifford Gerald Hansford, Thomas Leonard Lancaster, Maurice Burton, Sidney Phippen Heath, Narendranath Mitra, Herbert Ashby, and Edred John Henry Corner.

Certificates of recommendation of the following candidates for Foreign Membership were read for the first time :— Carl Erich Correns, Friedrich August Ferdinand Christian Went, Ludwig Diels, and Carl Christensen.

The President announced that the Council had unanimously resolved to award the Linnean Gold Medal for 1931 to Professor Karl von Goebel.

In accordance with Chap. X. Sect. VII. of the Bye-Laws, the following Fellows were elected, by show of hands, as Auditors of the Treasurer's accounts for 1930–31 :—

Representing the Council :	Dr. E. J. Butler.
	Dr. Philippa C. Esdaile.
Representing the Fellows :	Mr. R. H. Burne.
	Mr. R. Paulson.

Captain Guy Dollman exhibited some abnormal elephants' tusks with the following communication on "Four-tusked elephants" :—

The incisors of the Proboscidea consist of ever-growing teeth of great size ; in modern types these incisor teeth are limited to a single pair in the upper jaw, but in the fossil *Tetrabelodon* we find a pair of similar tusk-like teeth in the

lower jaw as well. The tusks of an elephant have sometimes been regarded as canines, owing to their roots being embedded in the maxillæ instead of the premaxillæ. But this view gains no support from the facts of the case : the tusks originally develop in the premaxillæ, and in these bones their primitive alveoli are situated. As growth proceeds, however, and the tusks get larger and heavier, in order to find a suitable alveolar emplacement it becomes necessary for them to seek firmer foundation. To this end the tusks are forced to sink gradually through the premaxillæ and come to rest in the specially modified alveolar processes of the maxillæ. This does not interfere with the relationship which these teeth bear to the incisors of other mammals : the homology remains. A very similar condition is met with in certain rodents. The tusks are composed mainly of solid dentine, the ivory of commerce, which exhibits in transverse section the well-known "engine-turning" pattern. In existing species the enamel covering is confined to the extreme tip, and is very soon worn off.

These proboscidean incisors have small milk predecessors which are shed quite early in life. This might possibly account for the occurrence of a four-tusked elephant, and this explanation has been accepted by some authorities as accounting for the abnormality. The possibility of the milk incisors persisting and being retained throughout the animal's life, side by side with the permanent teeth, cannot be denied ; but no specimen exhibiting this peculiarity has been recorded, and there is no evidence that the proboscidean milk-dentition will persist until maturity.

Various abnormal tusks have been recorded from time to time ; the most common abnormality takes the form of a shapeless mass of ivory developed close to the alveolar border. Elephants with one tusk broken off short are not uncommon among the herds in bush country, probably the outcome of a habit these animals have of using their tusks to prize up the roots of trees in order to get at the foliage.

In 1919 an officer in the Egyptian Army published a short account, 'Sudan Notes and Records,' vol. ii,of a four-tusked elephant which he observed at fifteen yards near Yambio in the Sudan in 1917. The left tusk was bigger and more or less normal, but the small tusk on the same side was bent downwards and came out from underneath the big one. The right tusk was inclined downwards, in a sort of Dinotherium-like manner, while the small tusk emerged from underneath the large one and was inclined forwards, more or less normally. The observer failed to secure the specimen, whose appearance we are left to judge from a very poorly executed diagram.

In 1926, a letter to 'The Times' from Captain Tracy Philipps, dated January 13th, mentions that when in the

Belgian Congo, in 1921, he heard of four-tusked elephants for the first time in the Welle River district. In 1925, again in the Zande country, at the residence of the Vongara-Zande Sultan Ngilima, the Sultan told him that he had killed a four-tusked elephant some years previously, and not realising that it was anything exceptional had disposed of the ivory through the ordinary channels. Some months after this, Captain Philipps was hunting on the Congo-Nile Divide when his trackers reported the presence of a large elephant which they called a "*siyamma*" or four-tusker, the word "*siyamma*" being that used by the Sultan Ngilima when describing his four-tusked elephant. The letter ends:—"It is, I would suggest, possible that the four-tuskers of the Welle-Shari may be rarely recurrent types, and something more than mere accidental freaks of nature." In a second letter (Jan. 21), he pointed out, in regard to the specimen referred to above as observed near Yambio, that, although one side might be the result of a basic split in the root of the tusk, which had subsequently grown into two malformed tusks, it was extremely unlikely that such a remarkable coincidence should occur in both tusks of a single animal.

On January 22nd ('The Times') Dr. R. T. Gunther, of Oxford, stated that for many years he used to demonstrate the possibility of a four-tusked elephant by exhibiting a large double elephant tusk (now in the Royal College of Surgeons), each half of which was apparently fully grown, about 4 inches in diameter and had a separate pulp cavity. Captain Tracy Philipps wrote again quoting the experiences of Mr. Gilbert Bussey, who, on a shooting expedition in the Congo, had received reports of several four-tuskers and had also seen the skull of a three-tusked female elephant at Dungu; the two tusks in one socket were quite separate. The tusks weighed about 8 pounds each.

In 1928 Captain Tracy Philipps published in 'The Times' evidence of Major Black and Major Larkin as to the existence of four-tuskers among the Zande of the Belgian and French Congo and Anglo-Egyptian Territory, and stated that the three-tusker observed by Mr. Bussey had been sent to the Belgian Congo Museum, and that the animal had been shot by the Sultan of Zande. Dr. Christy wrote referring to the four-tuskers as "teratological monstrosities" and "quadricorns"; having travelled extensively in the Zande country he had never seen or heard of a four-tusked elephant.

It appears from all this correspondence that the elephants in the Shari-Welle district have a tendency to develop supernumerary tusks: or, as I should say, that the tusks, for some cause unknown, tend to break up into distinct and separate units, pathologically, or as the result of accident.

In 1926 the Natural History Museum received a very interesting tusk from Major Holland in the Sudan. It bears a supernumerary root along one side near the base, which is continued upwards almost as a separate member to coalesce with the main shaft some distance further up. Quite recently, within the last few weeks, the Museum has received from the Game Department of Uganda three very interesting tusks collected by Mr. Jardine. Two came from the same beast, a female. The right tusk has five roots, for the most part joined together; at the tip these semi-individual members fuse to form a club-like organ. It looks as though some pressure had been brought to bear upon the outside of the base of the tooth, thus affecting the soft growing tissues and causing this area to assume an ever increasing ridged appearance, until the depressions between the ridges get sufficiently deep to separate some of the ridges from the main stock, thus forming the individual units.

In the other tusk the arrangement is carried still further, for here the individual units are free at their tips, so that, instead of a single tusk, we have four small tusklets. On careful examination, although these four tusklets appear more or less individual in the basal part, they seem to conform to a common apical outline at the tips and appear in this region to have been split asunder by the growth of the bony matter separating the ridges or individual roots below. This, I think, is the real reason for these abnormalities: the pressure of the alveolar bony tissue is so great as, firstly, to cause grooves in the tooth, and then to force the bone in between these grooves thus breaking the tooth up into two, three, four, or five separate elements; finally, in rare cases, as in the present one, the amount of bony growth is so great that the tooth splits at the top into two or more parts, just as a log will split when a wedge is hammered into its base. In this specimen the tips of the four tusks are clearly parts of the apex of the parent tusk.

The third example is that of a male, very much like the left female tusk just described, having three complete divisions and one broken one.

Sir Frank Colyer (November 1930, 'Journal of the Bombay Natural History Society') deals with abnormal tusks of Indian as well as African elephants, and figures a multiple tusk of a "rogue" Indian elephant which was composed of seven small tusks, six of which are shown in the photographs. Many cases are mentioned of multiple tusks produced by injury, and figures are given of subsidiary tusks similarly developed. Mention is made of a multiple tusked elephant referred to in Chapman's 'Travels in the Interior of South Africa,' the specimen having five tusks on one side and four on the other.

This is the only record that I can find of this abnormal condition occurring in South African specimens, all the other African examples coming from East and East-central Africa, with exception of one tusk which was received by the Natural History Museum so long ago as 1865 as coming from West Africa; but it may well have really come from any part of the continent. Many thousands of elephants were shot in South Africa during the last century, and it is a notable fact that more cases of these abnormal tusks have not been reported from the country south of the Zambesi.

I think these new specimens from Uganda clear up the problem of the four-tusked elephant. No member of the genus *Tetrabelodon* is shown existing at the present day, we must agree with Dr. Christy that these four-tuskers are "teratological monstrosities."

Dr. W. T. Calman exhibited, for comparison with the specimens shown by Capt. Dollman, an object sent to the Natural History Museum a few days previously, of which the origin and history were not known. It was a nearly straight, irregularly cylindrical, piece of ivory, now broken into two parts, about 14 inches in total length and 1¾ inch diameter. The nodular surface strongly suggested growth by apposition from the outside, not, as in a tooth, from an internal cavity. The most probable suggestion (due to Mr. R. H. Burne) was that it was a "pulp-inclusion" formed inside an elephant's tusk.

Lt.-Col. J. H. Tull Walsh, having commented on Dr. Calman's exhibit, the President expressed the thanks of the meeting to Capt. Dollman.

Mr. J. Ramsbottom, on behalf of Professor J. Small, exhibited four albums of water-colour drawings of British plants by Mr. F. Morton, a retired Civil servant. The President expressed the thanks of the meeting to Mr. Ramsbottom, Mr. Morton, and to Professor Small.

Some New Zealand indigenous-induced weeds and indigenous-induced, modified, and mixed plant-communities. By Dr. L. Cockayne, Mr. G. Simpson, and Mr. J. Scott Thomson.

In the absence of Sir Arthur W. Hill through illness, Mr. V. S. Summerhayes (Visitor) read this paper. The following is the authors' abstract:—

The paper deals at some length with the effect of settlement upon the vegetation of New Zealand and is, in part, a supplement to L. Cockayne's treatment of the subject in 'The Vegetation of New Zealand,' ed. 2 (1928). The subject-

matter is arranged in four parts, the first being of a general character. Here it is stated that the flora of the New Zealand Region consists of 1850 species, 427 groups of species hybrids, a great many varietal hybrids, and 650 introduced (exotic) species, and out of these diverse elements, the indigenous and exotic, a new vegetation is being constructed or has already come into existence. For the description of the vegetation the following terms (mostly self-explanatory) are defined :—Primitive, Modified, and Induced, this separated into Indigenous-induced, Exotic-induced, Mixed, and Artificial. The question of the supremacy of either group, exotic or introduced, is gone into, and the time-honoured statement, even yet part of the creed of many overseas biologists, of the exotics wiping out the indigenes when they come to grips, is declared to be fallacious, on the evidence afforded by many examples given later in the body of the paper. On the contrary, the indigenes are shown to be all-powerful in their own domain and the bulk of the exotics to be confined to cultivated land and ground laid bare by man ; also, in any case in the " struggle " between exotic and indigene, the former is almost always greatly aided by the direct or indirect action of man—cultivation, burning, attack of introduced domestic and feral mammals—the latter especially harmful to the New Zealand vegetation, which has assumed its structure and composition in the absence of such animals. It is also shown that the indigenes and exotics belong mostly to distinct ecological groups and have different preferences as regards habitat.

In the second part a number of cases are described in which indigenous plants, freed from their shackels by the novel conditions man has introduced, have become true weeds of artificial pastures and other economic plant-communities, originally primitive, but now being exploited by man, and this has occurred in competition with exotics. Such details should be of general interest, since the origin of the great host of European weeds is wrapped in obscurity, no plant being a weed in a primitive vegetation. The following cases of indigenous-induced weeds are discussed :—Grassland weeds : species of *Cassinia* (ericoid shrubs—Compositæ) ; *Coriaria sarmentosa* (summer-green, spreading, with far-extending underground stems—Coriariaceæ) ; species and hybrids of *Acæna* (far-spreading, semi-woody, open mats—Rosaceæ) ; *Histiopteris incisa* and *Pœsia scaberula* (stoloniferous ferns) ; *Rumex flexuosus* (rhizomatous, forming irregular mats—Polygonaceæ). Various more or less important weeds including *Arundo conspicua*, *Phormium tenax*, *Pimelea prostrata*, and *Celmisia spectabilis* ; the most aggressive species of all, *Pteridium esculentum* and *Leptospermum scoparium*, which

exceed far and away any exotic in the area they occupy, are not dealt with, since they have received considerable attention in various publications. Forest weeds: several stoloniferous tree-ferns and semi-tree-ferns, their vegetative increase being a recent and unexpected discovery, many dense shrubs, mostly of the divaricating life-form, which cut off much light from the ground; and indigenous trees and shrubs coming in as undergrowth in plantations of exotic trees. Weeds of cultivated ground: these are almost absent, but many high-mountain species introduced into gardens where the climate is favourable increase greatly both by seeds and vegetatively, and a list of such is given.

The third part treats of indigenous-induced plant-communities. These are usually early successions and generally differ from any such in the primitive vegetation, though the climax to which they lead may be equivalent to some existing primitive climax. New indigenous-induced communities range from those of absolutely bare ground to those intercalated in some primitive association. In nearly all cases in the making of induced communities Nature has both exotics and indigenes at her disposal but, where the ground is unbroken, generally only the latter are selected. The following indigenous-induced communities, or groups of such, are dealt with at some length :—Grass and herbaceous plant communities: *Danthonia pilosa* grassland, unknown in primitive New Zealand, but now of physiognomic importance, is induced either by the frequent burning of lowland or montane low tussock-grassland or it naturally replaces certain second-class artificial hill pastures of European grasses and clovers; induced low tussock-grassland, exactly resembling the primitive association, frequently occupies the ground after montane or lower-subalpine *Nothofagus cliffortioides* forest has been burned; mat or turf communities in modified montane low tussock-grassland of various composition, accompanied by a few exotics, have come into being where the close-growing dominating tussocks of *Festuca novæzelandiæ* have been burned again and again; domination of a deep hummocky carpet of *Raoulia glabra* occurs in the lower subalpine belt of the Humboldt Mountains as a first succession after the complete burning of the *Nothofagus* forest, but is now being invaded by certain subalpine shrubs and herbaceous plants, so that its ultimate destiny may be shrubland or forest; in Chatham Island a number of indigenous species hold their own as a mixed turf in the presence of the highly-aggressive exotic *Poa pratensis*, the most important indigene being *Pratia arenaria*; certain bowling-greens have been invaded by various indigenes which have almost replaced the original sown grass or grasses, their seeds brought by watering or top-dressing

the green; through burning the original forest-covering subalpine fell-field has been induced in certain localities and is now indistinguishable from a primitive community; so, too, burning subalpine-scrub of wet localities leads to induced herb-field. Ligneous communities: the small tree *Aristotelia serrata* is a most characteristic feature of the primary succession after felling or burning rain-forest proper; a rather striking forest community dominated by *Brachyglottis repanda* occurs near Wellington City, where the tall trees have been cut out of the semi-coastal forest; the old stony bed of the River Otira from which the forest had been renewed prior to the making of the railroad track was soon occupied by incipient forest with the subalpine low tree *Olearia ilicifolia* abundant and the rather rare *Rubus parvus* making colonies on the bare ground; felling and burning rain-forest proper in lowland Westland frequently leads to the establishment of shrubby bog with abundance of *Sphagnum* and great tussocks of *Gahnia rigida* characteristic; the burning of boggy montane *Nothofagus* forest containing various small podocarps led on a certain saddle of the North-west District to the incoming of several distinct communities, one of them dominated by small wiry cushions of *Cyathodes empetrifolia*; on earth cuttings along roads in Westland various ferns and lycopods are greatly in evidence, especially *Gleichenia Cunninghamii*; the epiphytic ferns *Polypodium diversifolium* and *Cyclophorus serpens* frequently occur in abundance on exotic trees with rough bark. New ground made by man and devoid of plant-life, in the presence of plenty of exotics in the immediate neighbourhood, may be occupied almost entirely of indigenes, as in the gold-mining tailings of Westland, where there is now potential rain-forest proper but not quite the same as that of the neighbourhood. Rock cuttings in many lowland localities often bear a mixed community with exotics and indigenes in about the same numbers.

The fourth part gives a few examples of vigorous exotic-induced communities being invaded and in course of suppression by indigenous trees and shrubs. Thus thickets of *Ulex europœus* near Wellington are being actively invaded by tree-ferns, trees, and shrubs from the adjacent semi-coastal rain-forest. Shrubland of *Leycesteria formosa*, *Hypericum androsœmum*, and *Cytisus scoparius*, near Dunedin, are being overwhelmed by species of *Leptospermum* in one spot, and, in another, by species of *Pittosporum*, *Coprosma*, and other forest plants. Also, near Dunedin, indigenous-induced bracken and many small exotics and indigenes are being strongly invaded by *Phormium tenax*. Another interesting case is the quite unexpected invasion by *Aciphylla Colensoi* of a mixed grass and herb community heavily grazed for many years.

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The paper gives many more details concerning the relation, etc., between the indigenous and introduced plants, together with general statements as to the causes of certain events and suggestions as to general principles. Perhaps, however, the most important pronouncement is that if all grazing and browsing animals were removed from North Island and South Island and Nature alone was permitted to work in her own way, in one hundred years' time forest would occupy most of the land up to the timber-line.

There was no time for discussion, but the thanks of the meeting were given to the authors and to Mr. Summerhayes.

The Biological Importance of Brownian Movements (with Notes on Sponges and Protista). By G. P. Bidder, Sc.D.

The great discoveries by Robert Brown, F.L.S., of the movements of small particles in 1827 and of the cell-nucleus in 1831, may have been first consequences of improvements in the microscope effected by J. J. Lister in 1824, 1826, 1827, and 1830 *. The Brownian movements were an unexplained curiosity for fifty years and the subject of ingenious conjecture for another thirty years. Then Einstein's theory † in 1905, experimentally proved correct in 1908 by Perrin and De Broglie, made them in the hands of Millikan and others the means of determining the charge on an electron and the number of molecules of gas in a cubic centimetre. Thus resulted also, in Ostwald's words, "the experimental proof of the atomic theory" ‡.

I suggest that Robert Brown's discovery is of importance to the biologist as well as to the physicist. Among all minute organisms in still water or air, and in many physiological relations of animals, the Brownian movement must have been among the fundamental physical conditions without which the history of living creatures could not have been as it has been. Especially we may consider the dissemination of spores, and the ingestion of minute particles of food.

* Joseph Jackson Lister (1786–1869), zoologist and histologist, published the theory of aplanatic foci in 1830. He was the father of Lord Lister and of Arthur Lister, F.L.S., the father in his turn of J. J. Lister, F.L.S., and Gulielma Lister, F.L.S.; so that the compound microscope which he perfected was notably used by his own offspring to the great advantage of the world.

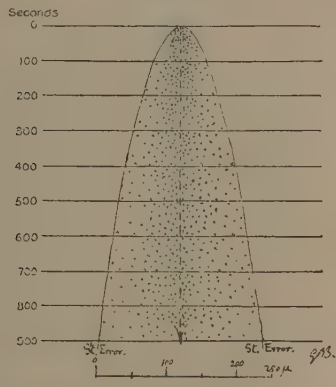
† Einstein's formula is quoted in the Appendix, where will also be found the arithmetical bases of statements in the text.

‡ *Fide* Millikan, 1917.—His book explains for the inexpert reader the theory of the movements, and of molecular and electronic physics; it is the authority used in this paper for theory and history of the subject.—See "References," p. 95, for titles of this and other works quoted.

(1) *Dispersal of Germs and Gametes.*

The researches of Barnard and others have indicated that there may be great importance to the world in the activity of filter-passing organisms, invisible to the ordinary microscope and of the order of magnitude of one ten-thousandth of a millimetre in diameter.

TEXT-FIG. 1.



Graph showing the progressive horizontal scattering by Brownian Movements of $\frac{1}{10}\,\mu$ spheres in water of 15° C. during fifteen minutes. The parabola indicates the magnitude at any moment of the standard horizontal error from their former mean position. The black dots are not to scale, but the same number is shown in each stratum; so that if the diagram be considered to represent a transparent paraboloid their increasing separation is approximately proportional to that of the germs. In a complete diagram other dots should be drawn outside the paraboloid, with density diminishing rapidly outwards as shown in text-fig. 2.

Text-fig. 1 also represents, greatly shortened, the vertical profile of the nucleus of a cloud of $6{\cdot}4\,\mu$ spores falling in still air from a single point. The horizontal scale is about 3000 times the vertical scale when this is treated as a scale of length, since, by Buller's experiments (1909), for $6{\cdot}4\,\mu$ spores 900 seconds in air represents a descent of $15\frac{1}{2}$ cm. (155,000 μ).

As shown in text-figs. 1 and 2, and calculated in the Appendix, 10,000 germs of $0{\cdot}1\,\mu$ in diameter—which could easily be contained originally in a $3\,\mu$ sphere—will be separated by Brownian movements in water of 15° C. so that after a quarter of an hour 3000 of them are outside a sphere $\frac{1}{4}$ mm. in diameter, and a few of them are outside a millimetre sphere. On the average of a large number of cases, there would be $7\frac{1}{2}$ germs outside a sphere of ·95 mm. diameter, which would be enough to supply one germ for each two-fifths of a square mm. of the

sphere's surface. In 15 minutes, therefore, without the germs having any power of locomotion, their Brownian movements have enabled them to infect adequately a sphere ·95 mm. in diameter—that is, 32 million times their original volume.

Cocci 0·4 μ in diameter would in the same time be jerked apart through half this distance in water, occupying a sphere $\frac{1}{2}$ mm. in diameter. Of them 10,000 would pack loosely in a 12 μ cluster, so that the expansion in volume is 600,000 times. But, dry in still air, in 15 minutes they would infect a sphere $3\frac{3}{4}$ mm. across, and so also occupy 32 million times their original volume.

The passive distribution of 0·4 μ spheres in water concerns Protista as well as cocci. Among living *Grantia*, in Plymouth sea-water, I have sketched a cyst, 15 μ or 20 μ in diameter, bursting and emitting spores or microgametes which measured 0·3 μ to 0·6 μ; another similar cyst had microgametes of 0·5 μ to 1·1 μ; a third, $7\frac{1}{2}$ μ in diameter, apparently already burst, still held attached to the wall a few cells reaching 1·0 μ. (Many things suggested that these were gregarine cysts, though the gregarine cysts found by Mackinnon and Ray, 1931, at Plymouth are as large as those in fresh water.) In 1920 *a* I described *Syncrypta spongiarum*, sp. n., from Plymouth Sound and Naples, having a 16-celled sphere only 3 μ to 12 μ in diameter and monads 0·5 μ to 3 μ. For many obvious reasons classic descriptions of reproduction in Protista are usually based on far larger freshwater gregarines and flagellates: but freshwater life is quantitatively negligible, since it requires 50,000 years' flow of all the rivers to equal the volume of the sea. The fact that, in water, 0·4 μ germs from a 12 μ cyst will be passively distributed in fifteen minutes so as to pervade a $\frac{1}{2}$ mm. sphere—more than half a million times the cyst's volume—is of biological importance in the present world, and is of still greater importance if we consider the dawn of life and the spread of reproductive fragments of unorganised protoplasm *.

Since the linear measure of dispersal in air is eight times that of the dispersal in water †, text-fig. 1 is also a graph and a diagram of the scattering in air of spores whose diameter

* Possibly flagella arose when such fragments became too large for effective Brownian distribution.

† The resistance of a fluid to the movement of small spherical particles is proportional to the coefficient of viscosity and to the diameter of the particles. Since at 15° C. the viscosity of air is 1/64th that of water, particles of 64 times the diameter will only encounter the same resistance. Consequently text-fig. 1 is also a graph for the dispersal in air of particles 6·4 μ in diameter; for the mean kinetic energy of every particle or molecule at any one temperature being identical (by Maxwell's molecular theory), the mean product of the resisting force and the distance travelled must be constant.

is $8^2 \times 0{\cdot}1\ \mu$—that is, $6{\cdot}4\ \mu$. The result may be worth the attention of mycologists. Text-fig. 2 shows that, on a horizontal floor, such spores, falling through 1 metre 40 cm. from a single point, would occupy a circle $\frac{4}{7}$ mm. in diameter (780 μ).

TEXT-FIG. 2.

Distribution on level ground of 10,000 spores, $6{\cdot}4\ \mu$ in diameter, which have fallen from a single point through air for 15 minutes: the numbers (interpolated from Sheppard 1903) show the probable number of spores in each circular zone. The dotted circle "Standard Error" corresponds to the base of the paraboloid in text-fig. 1.

Text-fig. 2 also represents the *horizontal* scattering of ten thousand $\frac{1}{10}\ \mu$ germs after 15 minutes in water, the spherical cloud being viewed from above and every germ counted. This representation under-rates the scattering in *space*, since a germ 0·4 mm. above or below the centre is counted as not having moved. The radius of the horizontal circle over which is contained a given proportion of the germs must be multiplied by $\frac{\sqrt{3}}{\sqrt{2}}$ $(=1{\cdot}22\ldots)$ to give the radius of the sphere containing the same proportion af the germs: thus $7\frac{1}{2}$ out of 10,000 will probably be outside a sphere $(1{\cdot}22 \times {\cdot}78$ mm.$=)$ ·95 mm. in diameter, and $62\frac{1}{2}$ will probably lie in the shell between this and the sphere ·76 mm. in diameter.

Buller found that the 5 $\mu \times 3$ μ spores of *Collybia dryophila* fall at only ·5 mm. a second *. Taking their mean diameter as $3{\cdot}7\ \mu = {\cdot}58 \times 6{\cdot}4\ \mu$, they would be dispersed as much as 6·4 μ germs in ·58 of their time ; so that text-fig. 2 represents the distribution on the ground in 520 seconds—that is, after a fall of 26 cm. A few Fungi Imperfecti have spores only 1 μ in diameter (*Isaria* is described in caves by Lagarde, 1913, p. 288, with spores 0·5 μ to 2 μ) ; they would acquire the distribution of text-fig. 2 after 140 seconds. They would fall at $\left(\frac{1}{3{\cdot}7}\right)^2$ of the rate of *Collybia*—that is, at the rate of ·037 mm. a second ; so that text-fig. 2 represents their scatterment on a horizontal surface after a fall through still air of 5·2 mm. Buller (p. 146) describes the explosive mechanism of the basidium in Hymenomycetes, which has the advantage of separating the adhesive spores from the gills of the fungus and from each other ; he found in *Amanitopsis* that the maximum horizontal distance to which the spore is carried by the explosive is 0·2 mm. Since the Brownian movement will carry one-twelfth of the 1 μ spores to this horizontal distance from their centre, during a fall through 5 mm. of still air, is it not possible that it is the advantage of this separation and distribution which has led to evolution, in certain fungi, of small size in spores ?

(2) *Ingestion of Food.*

I was led to consider the Brownian movements by the apprehension that they explain an experiment in the feeding of sponges, which had puzzled me for forty years. The experiment was as follows :—

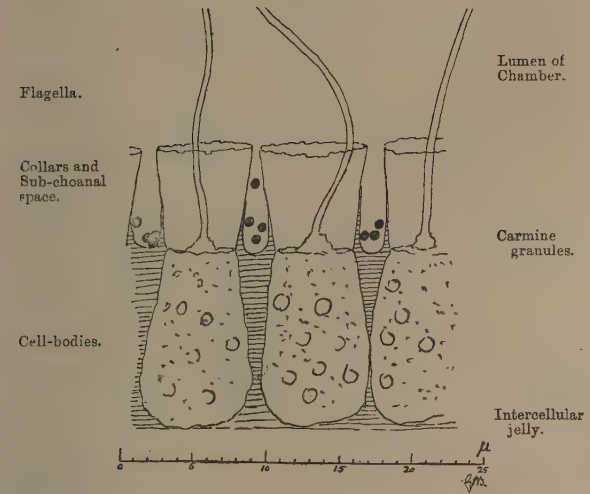
" I observed that during four hours a *Leuconia* plentifully supplied with carmine ejected none in its oscular stream, which was powerful and continuous. Its flagellate cells proved to be heavily charged with carmine grains. Such complete filtration would be uneconomical, if not impossible, were the carmine arrested merely by the ingestion of cells laterally bounding the current " (1888) †.

* 1909 (p. 175).—I owe to Mr. J. Ramsbottom's kindness my acquaintance with this interesting book and with Lagarde's descriptions of cave fungi. I suggest that the 50 per cent. excess found by Buller over the velocity calculated from Stokes's formula may be due to the air being set in motion by the continuous stream of falling spores.

† See also Bidder, 1895, p. 29, footnote.—Lieberkühn (1856, p. 497) saw carmine rapidly taken into the chambers of *Spongilla*, but it was three hours before it began to appear at the vent.—Bowerbank (1857, p. 121) in *Spongilla* found " it is remarkable that although the finer molecules of indigo were being imbibed by the pores in very considerable numbers, very few of them indeed were ejected from the osculum." See also 1864, Mon. Brit. Sponges, i, p. 93.—Carter (1859, p. 12) stated that indigo is entirely taken up by the collar-cells of *Spongilla*, none entering the lumen of the flagellate chamber ; Van Trigt (1919, p. 145) found a particle of carmine enter the lumen " only very rarely."

Leuconia (= *Leucandra*) *aspera* is a calcareous sponge. The water enters by antler-shaped afferent canals which envelop the outside of thimble-shaped chambers lined with flagellate collar-cells, these drive the water into efferent canals and the cloaca, and out by the vent (=osculum). Holes about 14 μ wide, known as prosopyles, in the wall of each chamber allow access to its cavity from the afferent canals; but the adjacent collar-cells lean over the prosopyle so that there is only a crevice open between their collars, not greatly larger than the crevices between any neighbouring

TEXT-FIG. 3.



Diagrammatic representation of collar-cells in a Calcaronean sponge, with the intercellular jelly shaded horizontally. The black dots represent carmine granules in the water which is passing through the sub-choanal space.

collars (my text-fig. 8, 1921, p. 401, fails to show this masking of the prosopyle). The water in the chamber is at a higher pressure (maintained by the flagella) than that of the afferent canals, consequently water can only enter the chamber as it is dragged in, between the collars, by the stroke of the flagellum pushing back water into the chamber, whence it is free to issue by the mouth of the thimble and so to the vent. Between any two neighbouring prosopyles there are 4 or 5 collar-cells, so that from the prosopyle a particle of water may be dragged tangentially past $2\frac{1}{2}$ cells before it issues radially between

the collars into the chamber. The circumference of the base of a collar is about 20 μ, so that, if the average journey be half round one collar and one-third round another, its average length is about 16 μ; and since, according to my observations (1921, p. 304, slightly corrected), its speed is about 10 μ a second, we may take it that water usually spends about 1·6 seconds in the "sub-choanal space" between the collar-bases, travelling tangentially, before it turns upwards to enter the chamber. Water cannot enter straight through the prosopyle except in so far as the flagella neighbouring the prosopyle drag it in against the chamber pressure; if there were no flagella in action above the prosopyle the water would come out through it from the chamber, if it were not stopped by the neighbouring collars opening against each other like bell-valves.

Text-fig. 3 shows the approximate form and dimensions of the sub-choanal space in life, deduced from living sections and stained paraffin sections (*cf.* Van Trigt, 1919, figs. 63, 65, 66). A watery intercellular jelly, invisible in life, lines the space *, and after feeding with carmine is densely packed with carmine granules.

The single carmine granules were about ·55 μ in diameter, and the channel through which they pass is rather more than three of these diameters in width. The difficulty of understanding the complete removal of the carmine was that with the parallel stream-lines of viscous flow (in which water moves at this slow velocity through fine channels) it seemed impossible that a granule in mid-channel should do otherwise than remain in mid-channel throughout its journey. Once, however, it is recognised that the Brownian movements will jerk such a granule in every direction, it becomes a matter for calculation what percentage of such granules will strike the side in 1·6 seconds. The calculation is attempted in the Appendix, on the simplified assumption that the carmine proceeds for 1·6 seconds between two parallel walls 1·7 μ apart, and that every granule which touches a wall adheres there and is absorbed. On this assumption it appears probable that only one granule would issue from the channel out of a quarter of a million entering it; but such a rough calculation does not take into account the additional toll of granules striking the bottom of the channel; nor the fact that the granules, adhering to the walls, rapidly make the channels narrower; nor the fact that, beside single granules, the most careful rubbing leaves a large proportion of the carmine in aggregates of two, three, or more granules which will obstruct the channels

* Described by Lendenfeld (1891, p. 161, fig. 101), Dendy (1891, p. 11; fig. 3, pl. viii), and Bidder (1895, p. 22; text-fig. *a*, p. 14).—The 20 μ circumference assumes a coating of jelly ·9 μ thick.

still more importantly, and especially near the prosopyles where the subchoanal journey is short. It is not surprising, therefore, that I was unable to detect any carmine at all issuing from the sponge *. We can understand that the transverse component of the Brownian movements lodged practically every grain of carmine on the glutinous sides or bottom of the tiny channels between the collars of the sponge, so that not one grain out of the many millions administered was seen to emerge.

Many will share with me relief from a difficulty in conceiving how, in other animals, minute particles of food come into actual contact with the protoplasmic surface which ingests them. We may instance the feeding of the choanoflagellate, as described by Lapage (1925, p. 496 *et seqq.*), where the flagellum draws the water past the surface which ingests the food ; we may consider the progress of a minute flagellate or swarm-spore through the water from which it takes it food. Were it not for the Brownian movements, particles in the water would move parallel to the surface which limits the current, and none would strike that surface except the rare particle moving in the outermost layer. Remembering that the ultra-microscopic particle (say, $\frac{1}{10}\,\mu$ in diameter)—which must supply most of the food of these small creatures—would be jerked by the Brownian movements more than twice as far and as fast as the carmine grains (so that, in a second, half of them would be $1{\cdot}8\,\mu$ nearer to or further from the limiting surface than they were at the beginning), the difficulty appears to vanish. If we allow only one-tenth of a second for the stream to pass the ingestive surface of the flagellate, in that time a quarter of the small particles will have moved $\cdot 6\,\mu$ nearer the surface, so that the small flagellate can ingest a quarter of the food from a flowing film of this depth †.

In this way we can understand how, in the dawn of our kingdom, a photo-synthetic flagellate, wholly unprovided with any ingestive mechanism, might be enabled to adopt the feeding-habits of an animal without other variation than that a part of its protoplasm should be naked, except that it should be covered (as it frequently is) with a thin mucilaginous layer.

* Incidentally this investigation proves that Van Trigt (1919, passim) was right in saying that the food is mostly absorbed through the body-surface of the collar-cells, and that I was wrong (1895, pp. 29, 32) in supposing that ingestion through the area inside the collar might be the usual course. Such intrachoanal ingestion occurs where comparatively large bodies have been drawn past the collars above the prosopyle.

† Hence, in Hexactinellida, the possibility of nutrition for the trabecular cobweb of passive fusiform cells, naked in the water, which Ijima (1901) made known to us.

Respiratory Infection.—It may be worth mentioning that, for cocci in dry air at 15° C., the standard horizontal error after 9 seconds would be about $\frac{1}{20}$ mm., and therefore many would have moved as much as $\frac{1}{6}$ mm. across the flow of the air. This may possibly have importance in regard to infection of the bronchioles and air-cells, but the numerical calculation requires correction for the viscosity of air saturated with moisture at 37° C., and for the increase in diameter of the cocci owing to water condensing upon them. The preceding paragraph (and the last paragraph of the Appendix) explain the entrance of cocci into the epithelium of walls parallel to which the air is moving.

Temperature.—Tropical water at 25° C. will effect the same dispersal of germs 1·6 μ in diameter as temperate waters at 9° C. will effect for germs of 1·0 μ. For ingestion of food, sponges of the same anatomy in the tropics will extract the food equally well with their currents flowing 60 per cent. faster than in temperate seas; and this advantage is superimposed on the high mechanical advantage which their currents obtain from the lower viscosity *. All microphagous animals have similar advantages in tropical waters.

In air the dispersal alters very little with temperature.

Filtration.—I understand that it is recognised that the organisms retained on filtration are not always larger than those which are filter-passing, the difference being that the latter do not adhere to the wall of the pore in the filter when they strike it. From the discussion above of the ingestion of food in sponges, it is manifest that in a filter only $\frac{1}{2}$ mm. thick it must be very many times that a particle would strike the wall, owing to Brownian movements, during its passage through a pore even two or three times its diameter; so that quite small germs will be stopped completely by a filter to whose substance they adhere on contact.

Odour.—The particles which carry the scent of an organism must approach molecular size, and therefore will be subject to Brownian dispersal of several times the linear extent of that undergone by the $\frac{1}{10}$ μ germs.

* I pointed out this increased force of the currents in tropical sponges in a paper read to the 'Challenger' Society at Cambridge, 1923, but not yet printed, except for the development, in these Proceedings for February 1930, of a short paragraph on cataclasms.

Appendix.

(1) *Brownian Movements of small Spheres in a Fluid.*

At absolute temperature T, in a fluid whose coefficient of viscosity is η, Einstein shows that in a large number of observations, each over time t, a sphere of diameter d will end (say) to east or west of its position at the beginning of each observation by distances whose mean square is :—

$$\overline{\Delta x^2} = \frac{2\mathrm{R}}{\mathrm{N}3\pi} \cdot \frac{\mathrm{T}t}{\eta d}$$

(see Millikan, 1917, pp. 124, 245).

Substituting numerical values for the constants, the equation becomes :—

$$\overline{\Delta x^2} = \frac{2 \times 831{\cdot}5 \times 10^5}{6{\cdot}062 \times 10^{23} \times 9{\cdot}425} \times \frac{\mathrm{T}t}{\eta d}$$

$$= 2{\cdot}910 \times 10^{-17} \times \frac{\mathrm{T}t}{\eta d}.$$

This may be simplified further by considering only the temperature 15° C.=288° absolute, and so taking $\eta = {\cdot}0113$ for water and $\eta = {\cdot}00018$ for air ; therefore

$$\text{at } 15^\circ \text{ C. for water } \overline{\Delta x^2} = 7{\cdot}41 \times 10^{-13} \frac{t}{d},$$

$$\text{,, ,, air } \overline{\Delta x^2} = 4{\cdot}65 \times 10^{-11} \frac{t}{d}.$$

Where the number of observations is large, the " Standard Error " to east or west of the particle from its former position will be the square root of the average of the squares of the individual " errors " observed. The standard error parallel to a given direction is therefore :—

$$\text{at } 15^\circ \text{ C., for water } \mathrm{S.E.}_x = \sqrt{\overline{\Delta x^2}} = 8{\cdot}61 \times 10^{-7} \sqrt{\frac{t}{d}},$$

$$\text{,, ,, air } \mathrm{S.E.}_x = \sqrt{\overline{\Delta x^2}} = 6{\cdot}82 \times 10^{-6} \sqrt{\frac{t}{d}}.$$

Therefore for spherical particles, 1 μ ($=1 \times 10^{-4}$) in diameter, after t seconds.

$$(1) \begin{cases} \text{At } 15^\circ \text{ C. in water } \mathrm{S.E.}_x = {\cdot}86\,\mu \times \sqrt{t}, \\ \text{,, ,, air } \mathrm{S.E.}_x = 6{\cdot}8\,\mu \times \sqrt{t}. \end{cases}$$

For larger or smaller particles the right-hand side must be divided by the square root of the number of μ in the diameter.

This formula would be applicable if, with the microscope, the number were counted of divisions of the ocular micrometer traversed by a particle in successive periods of t seconds. If the micrometer measure the motion parallel to an axis of

x from W. to E., and be then turned through a right angle, there will be symmetrically the same $\cdot 86\,\mu \times \sqrt{t}$ for the standard S. to N. motion parallel to the axis of y. The actual horizontal distance of the second position of the particle from its first position we may call Δh, and, in the right-angled triangle, $\Delta h^2 = \Delta x^2 + \Delta y^2$, and for a number of such distances the sum of Δh^2 = sum of Δx^2 + sum of Δy^2.

Therefore, dividing each side by the number of movements, the mean square $\overline{\Delta h^2} = \overline{\Delta x^2} + \overline{\Delta y^2}$. But $\overline{\Delta x^2} = \overline{\Delta y^2}$.

Therefore the "Standard" distance $\sqrt{\overline{\Delta h^2}}$ between first and second position in the microscope field is

$$\text{S.E}_h = \sqrt{\overline{\Delta h^2}} = \sqrt{\overline{\Delta x^2} + \overline{\Delta y^2}} = \sqrt{2\overline{\Delta x^2}} = \text{S.E}_x \times \sqrt{2}.$$

This is the measure of horizontal scattering. For particles $1\,\mu$ in diameter at 15° C., which at the beginning of the observation were packed closely together, at the end of time t their standard error in the field of the microscope from their original position is represented by a circle with radius :—

$$(2)\ \begin{cases} \text{For water S.E}_h = 1{\cdot}22\,\mu\sqrt{t}, \\ \text{,,\quad air\quad S.E}_h = 9{\cdot}62\,\mu\sqrt{t}. \end{cases}$$

If we require to calculate the scattering in space, taking account of motion parallel to the axis of z, symmetry shows that in the air or in an unconfined body of water, $\overline{\Delta z^2} = \overline{\Delta x^2} = \overline{\Delta y^2}$, and if the line Δr be drawn in three dimensions from the first to the second position of a particle, $\overline{\Delta r^2} = \overline{\Delta x^2} + \overline{\Delta y^2} + \overline{\Delta z^2} = 3\overline{\Delta x^2}$. So that the standard error in space of the $1\,\mu$ particles from their original position is $\text{S.E}_r = \text{S.E}_x \times \sqrt{3}$, and (from equation (1)) after time t at 15° C. this marks out a sphere with radius :—

$$(3)\ \begin{cases} \text{For water S.E}_r = \cdot 86\,\mu \times \sqrt{3} \times \sqrt{t} = 1{\cdot}49\,\mu \times \sqrt{t}, \\ \text{,,\quad air\quad S.E}_r = 6{\cdot}8\,\mu \times \sqrt{3} \times \sqrt{t} = 11{\cdot}8\,\mu \times \sqrt{t}. \end{cases}$$

This sphere is at a distance equal to the Standard Error from the centre of dispersal, and, if a large number of particles have been subject to the random scattering, the theory of probability proves that about two-thirds of them will lie inside this sphere (out of 1000, slightly the most probable number is 683) and one-third outside. The so-called "Probable Error" is the radius of a sphere within which one-half of the particles may be expected to lie—so that the chances are even whether any one particle will be outside or inside. Though the "probable" sphere contains nearly three-fourths the number of particles enclosed in the "standard" sphere, they are more

densely packed, and it has only two-thirds the radius—more accurately P . E = ·6745 × S . E.

The normal curve of error shows further that of every 10,000 germs liberated at the centre, 70 will probably be found outside a sphere with radius four times the probable error, and $7\frac{1}{2}$ will be found outside the sphere with radius five times the probable error (*cf.* text-fig. 2)—that is, 3·373 times the standard error. Therefore with large numbers of germs, when the standard error after a given time has been determined, the region infected may be expected to have from three to four times this radius, and for 10,000 germs we may consider the infected region to have a radius=$3\frac{1}{3}$ (S . E.). From equation (3) this will give for 1 μ germs in water an infected sphere of radius 5·0 $\mu \times \sqrt{t}$, and for $\frac{1}{10}$ μ germs $\sqrt{10}$ times this—that is, 15·8 $\mu \times \sqrt{t}$; or for 900 seconds 474 μ, giving a diameter of ·95 mm. In the air, germs $\frac{1}{10}$ μ in diameter would in 900 seconds infect a sphere $3\frac{1}{3} \times 11{\cdot}8\ \mu \times 3{\cdot}16 \times 30 = 3730\ \mu$ in radius—that is, $7\frac{1}{2}$ mm. in diameter.

(2) *Rate of falling.*

Stokes's formula for the velocity of small spheres falling is

$$v = \frac{2g}{9} \cdot \frac{a^2(\sigma - \rho)}{\eta},$$

where a is the radius of the sphere, σ its density, ρ the density of the surrounding fluid, and η its viscosity coefficient.

Therefore for $\frac{1}{10}$ μ spheres with specific gravity 1·1, falling through water,

$$v = \frac{1965}{9} \times \frac{25 \times 10^{-12} \times 0{\cdot}1}{1{\cdot}12 \times 10^{-2}} = 4{\cdot}875 \times 10^{-8} = {\cdot}00049\ \mu,$$

so that in 900 seconds they fall 0·44 μ. Even for similar spheres of specific gravity 1·3, the descent in 900 seconds would be only 1·3 μ, so that, in water, we may say that organisms of this size do not fall.

The 1 μ spheres, being 10 times the diameter, fall 100 times as fast, and will therefore fall 44 μ in 15 minutes. It is conceivable that in the rough bottom of enclosed water there might be such shelter next the rock that there would be no swifter upward and downward movement than this. In such a case a 12 μ cyst elevated $\frac{1}{20}$ mm. above the bottom would sow it with the distribution shown in text-fig. 2, effectively inseminating an area 1100 times its own equatorial area.

Buller discusses in detail the rate of falling of spores through air, and their trajectory. On the latter, in considering text-fig. 1 as the fore-shortened diagram of a falling cloud of spores from a fungus, it must be remembered that the parabola does not indicate the course of spores. Every

spore zig-zags towards every point of the heavens in successive jerks and may emerge from the paraboloid and return to it. But at any moment spores inside the paraboloid will be about twice as numerous as those outside.

(3) *Ingestion of Food.*

Any general mathematical treatment of this problem is beyond the scope of this paper or its author. We can, however, consider an elementary model of the passage of carmine-charged water between two plane adhesive surfaces, which engulf any granule which touches them. The carmine is taken as being entirely composed of single spherical granules $\cdot 55\ \mu$ in diameter, the walls are $1 \cdot 7\ \mu$ apart, the time occupied in passing through the channel is 1·6 seconds.

For a spherical particle $\cdot 55\ \mu$ in diameter the square root of the number of μ in the diameter is ·74, so that equation (1), for movement parallel to a given direction—in this case, perpendicular to the walls,—becomes :—

$$(4)\ \begin{cases} \text{S} \cdot \text{E}_x = 1 \cdot 16\ \mu \times \sqrt{t}, \\ \therefore\ \text{P} \cdot \text{E}_x = \cdot 78\ \mu \times \sqrt{t}. \end{cases}$$

The following model may represent sufficiently the fate of a densely packed spate of millions of carmine granules entering thousands of the little channels :—

Let the granules be flowing in alternate ranks of three abreast and two abreast ; so that of 100,000 granules, 20,000 are "median" ; 40,000 are "lateral," $\cdot 15\ \mu$ free of the wall ; and 40,000 are "dangerous," not more than $\cdot 03\ \mu$ from the wall.

Of the last category if $\text{P} \cdot \text{E}_x = \cdot 03\ \mu$, then from (4), $\sqrt{t} = \frac{\cdot 03}{\cdot 78} = \cdot 04$, $\therefore\ t = \cdot 0016''$. Half of these granules will move inward, half will move outward, so that we may consider that a quarter of the lateral granules will strike the side in ·0016″ and a quarter of the remainder in the following ·0016″, and in eight times ·0016″,=·013″, they will be reduced to $(\cdot 75)^8 = \frac{1}{10}$ of their original number. Therefore, of the 40,000 "dangerous" granules, 36,000 will strike in ·013″. It will be noticed that those which move away from the wall will probably be stopped by a median granule, and will probably knock the "dangerous" granule on the other side of it into the wall. So that until the numbers are a good deal reduced the "dangerous" granules cannot easily emerge from their category. But they protect the median granules from divagation, and to a less degree the lateral granules.

Suppose that after ·013″ these 36,000 are all that are lost, and that the remaining 4000 "dangerous" granules have passed into the inner categories. In ·013″, $\text{P} \cdot \text{E}_x$ is

·78 $\mu \times$ ·115 = ·089 μ, and S . E_x is ·13 μ, therefore about one-third of the "lateral" granules will have wandered ·13 μ, and therefore one-sixth or 6600 are in the "dangerous" zone. Of these, 6000 will be extinguished in the next ·013″, making a loss of ·093 of the 64,000 which were left. The categories are now sufficiently mixed for us to assume that this is approximately the toll which will be taken every ·013″. In 1·67″, ·013″ will be repeated 128 times, therefore the number of granules issuing will be of the order of magnitude of $58{,}000 \times (\cdot 907)^{128}$:—

$\log\ (\cdot 907)^{128} = 128 \times (\bar{1} \cdot 95761) = 128 \times (-\cdot 04239) = -5 \cdot 426 = \bar{6} \cdot 574 = \log\ \cdot 00000375.$

So that of each 100,000 granules entering, an average of 0·375 would emerge, or 1 in 270,000.

On the question (p. 89) of the small monad feeding on $\frac{1}{10}$ μ organisms and fragments : at 15° C., for $d = 0 \cdot 1$ μ.

$$S \cdot E_x = 2 \cdot 7 \ \mu \times \sqrt{t},$$

$$P \cdot E = 1 \cdot 8 \ \mu \times \sqrt{t}.$$

Therefore if the monad's flagellum cause water containing these particles to flow over its surface, half the particles will move 1·8 μ nearer or farther from the surface in a second, and in $\frac{1}{10}$ second half will similarly move ·56 μ ; so that more than a quarter of the particles which started in the stream-line $\frac{1}{2}$ μ away from the monad's surface will nevertheless strike that surface.

[Postscript.—A physicist friend, who was kind enough to inspect the typescript for mathematical errors, writes as follows: "I have looked through your paper rapidly and have also got Dr. —— to look into one or two points. So far as I can see, the essential ideas are all right, although developed in rather an unorthodox way. In many cases the spread etc. are best dealt with by means of a diffusion coefficient which is connected with the radius of the particle and the viscosity of the medium. However, I have no serious criticism to offer."

I quote the above so that biologist readers may treat the numerical conclusions of the text as being founded on correct conceptions. I will trust them to pardon a struggling brother's inelegance in his mathematics.

Cambridge, June 11th, 1931.]

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The Botanical Secretary said with what pleasure he always listened to the Zoological Secretary's biological mathematics. As far as he himself was concerned, he had always thought of Brownian movements as an oscillation, and it was of considerable interest to learn that objects below a certain size could progress in water, and that in air their movement was eight times as great, for it seemed that this might be a factor in spore-dispersal.

The President, in congratulating the author of the paper on what appeared to him a most suggestive communication, remarked that Dr. Bidder's knowledge of mathematics and physics had qualified him for a task which few biologists would have been able to attempt. He had been specially interested in hearing Dr. Bidder's new explanation of the well-known observations made by him, some years ago, on the collar-cells of Sponges.

The following paper was read in title :—"The Fauna of the Swamps of the Paraguayan Chaco in relation to its Environment. III. Respiratory Adaptations in the Oligochæta." By Dr. G. S. Carter and Mr. L. C. Beadle.

30th April, 1931.

Dr. C. Tate Regan, F.R.S., Vice-President,
in the Chair.

The Proceedings of the previous Meeting, held on Thursday, the 16th April, having been circulated, were taken as read and confirmed.

A list of names of those who had made gifts to the Library since the previous meeting was read and laid on the table.

The following Fellow signed the Obligation in the Book of the Charter and Bye-laws and was admitted :—Gwendoline E. Kirby.

Certificates of recommendation of the following candidates for Fellowship were read :—For the second time, in favour of Joseph Davenport Snowden, Clifford Gerald Hansford, Thomas Leonard Lancaster, Maurice Burton, Sidney Phippen Heath, Narendranath Mitra, Herbert Ashby, and Edred John Henry Corner. For the first time, in favour of Rachel Elizabeth Harries.

Certificates of recommendation of the following candidates for Foreign Membership were read for the second time :—Carl Erich Correns, Friedrich August Ferdinand Christian Went, Ludwig Diels, and Carl Christensen.

The Vice-President in the Chair announced that the title of Sir Sidney Harmer's presidential address to be delivered on the 28th May, 1931, was "Recent Work on Polyzoa."

Hydrolysis in living Plants by Polarized Light: Effect of blue Sky-light on Plant Metabolism. With Exhibits. By Dr. E. S. Semmens (Visitor).

During the past six years a number of simple experiments have been carried out, showing that polarized light has the power of hydrolysing starch and other reserve products within the leaf of the living plant. An account of these experiments has been given in the 'Botanical Gazette,' xc (1930), p. 412. They were performed under very different conditions of temperature and light intensity in England, Canada, and South Africa, and gave consistent results which appear to be of importance in plant metabolism, for all plants are exposed to a constant succession of polarized and unpolarized light.

Issued August 28th.] h

The light of the morning and evening sky is strongly polarized. This light has a decidedly hydrolysing effect upon starches, glucosides, and other complex reserve substances within the leaf at temperatures considerably below those ordinarily associated with enzyme action. If a healthy young leaf is exposed to polarized light, the starch in the mesophyll of the exposed area breaks down, and on staining with iodine the exposed area is left as a lighter patch. The remarkable acceleration of the process of digestion thus produced must greatly increase the rate of growth of the plant. When plants are grown in polarized light succeeded by periods of darkness there is a disappearance of starch and other reserve products, a temporary phototropism owing to the increased turgor in the stem, and leaf-fall and signs of starvation.

Semi-permanent preparations were shown to illustrate several points, and included many of which photographs were published in the author's previous paper.

Prof. R. R. Gates remarked that the interesting exhibit of Dr. Semmens dealt with a subject regarding which there had been much discussion. It was not a matter on which he had any special knowledge; but various complicated physiological processes were involved. There was no certainty that her conclusions regarding the effects of polarized light were correct to the exclusion of other possible interpretations of the difference in starch content between the leaves exposed to diffuse skylight and the control leaves.

Dr. O. Rosenheim asked whether, in Dr. Semmens's opinion, the evidence for the assumption that polarized light induced hydrolysis of starch *in vitro* was sufficiently conclusive to warrant the theory advanced in explanation of her striking experiments with living leaves.

Mr. M. A. H. Tincker enquired whether the length of the daily light period had been considered, and remarked that similar starch differences can be induced in hairy and downy and smooth leaves by altering the light period of leaves detached from or attached to the plant. Quite possibly the quality of the light may also influence the rate of hydrolysis, as the incidence of ultra-violet rays has been shown to affect certain aspects of metabolism.

Lt.-Col. J. H. Tull Walsh stated that it is common knowledge that starch forms in the leaves of plants in sunlight and through subsequent hydrolysis passes into the body of the plants as sugars. Some of the light received is always naturally polarized. Would the addition of artificially polarized light make any difference?

Dr. G. P. Bidder remarked that on Dr. Semmens's theory a greenhouse with north–south ridge-pole would seem to give additional assistance to growth by reflecting polarized light

from the inner surface of the half of the roof in shade to the plants below it.

Dr. SEMMENS having replied, the Vice-President in the Chair expressed to her the thanks of the meeting.

The Hairs lining the Loculi of Fruits of Species of Parinarium. By Dr. J. M. Dalziel.

IN the genus *Parinarium* (Rosaceæ) the fruit is a drupe, generally with two loculi. The inner surface of the loculi is in most species clothed with hairs, and these vary to some extent in different species. Three types were demonstrated, illustrated by three African species—*P. Mobola* Oliv., *P. robustum* Oliv., and *P. Benna* Scott Elliot.

In the commonest type the hairs are long and slender and twisted, so that they become intricately involved and form a loose wool, often tawny in colour, almost filling the cavity which contains the kernel. Examples are :—*P. Mobola* Oliv. of South Tropical Africa, *P. excelsum* Sab. and *P. curatellæfolium* Pl., both with a wide range in West and East Africa, *P. tenuifolium* A. Chev. and *P. macrophyllum* Sab. in West Tropical Africa.

In *P. robustum* Oliv., a species with a limited range in West Tropical Africa, the hairs are curled, but reduced in length so that they form only a velvety cushion lining the loculi. In *P. Benna* Scott Elliot, a West African species known so far only from French Guinea and Sierra Leone, the hairs are perfectly straight, apparently hollow, needle-shaped spines which project stiffly into the cavity.

The loose wool common to the majority of the species is used all over Tropical Africa as tinder to catch the spark from flint and steel or from the primitive fire-stick. The spicular hairs of *P. Benna* are used medicinally, within its limited geographical range, as a vermifuge, a usage which corresponds with that of the irritating hairs of cowage—*Mucuna pruriens*—long known in India and Europe as used for the same purpose.

The thanks of the meeting were expressed by the Vice-President in the Chair.

Aquatic and Aerial Respiration in Animals. By Dr. G. S. Carter.

FUNDAMENTALLY all respiration is aquatic. The surface of the respiratory epithelia of organs of aerial respiration is covered by a thin layer of liquid, through which the gases entering or leaving the epithelium must diffuse. On the surface of the epithelia of organs of aquatic respiration there is also a layer of stationary liquid, held stationary by the

friction of the respiratory current on the surface of the epithelium. Diffusion controls the movements of the gases through this layer also. Since diffusion in liquids is by far the slowest of the processes governing the movements of the gases, the amount of the respiratory exchange is largely controlled by the rate at which the gases diffuse across these layers.

The stationary layer on the surface of the organ of aquatic respiration is much thinner than that on the surface of the organ of aerial respiration. It would therefore seem that, under similar conditions, organs of aerial respiration should be less efficient for the same area of respiratory epithelium than organs of aquatic respiration. Data of the respiratory area in the lower vertebrates confirm this conclusion.

Consideration of the physical conditions in the medium outside these stationary layers points to the conclusion that in organs of aerial respiration variations in the tension of carbon dioxide rather than in that of oxygen will control the respiration, and that in organs of aquatic respiration the reverse will be true. This conclusion is confirmed by such facts as, on the one hand, the control of respiration in the mammal and the slug (Dahr) by variations in the carbon dioxide tension, and, on the other hand, the greater secretion of carbon dioxide in the gill, and of oxygen in the accessory respiratory organ, of fishes which possess both these organs.

A striking difference between the fishes and the higher invertebrates is the much greater ease with which the latter can change from aquatic to aerial respiration. It is suggested that the steeper dissociation curves of hæmocyanin and of dissolved hæmoglobin, which are the typical respiratory pigments of the invertebrates, as compared with those of the types of corpuscular hæmoglobin which are found in the blood of the air-breathing vertebrates, are at least partly responsible for this difference. The steeper form of these curves implies that the pigment will become nearly saturated with oxygen at a much lower tension of the gas, and a decrease in the efficiency of the respiratory organ, such as the previous considerations have shown to occur when the respiration becomes aerial, will therefore be less likely to lower the tension of oxygen in the blood to a point at which the saturation of the pigment, and therefore the respiration of the animal, is markedly affected.

A difficulty in the way of such an interpretation lies in the fact that Krogh has shown that the blood of some of the common fresh-water fishes contains a type of hæmoglobin which has a steeper dissociation curve than that of other vertebrates, and steeper than that of hæmocyanin. However, he found that hæmoglobin of this type is extremely sensitive to the presence of small amounts of carbon dioxide in the air with

which it is in equilibrium, and that, as a result of this, it is never saturated in air in which as much as 2 per cent. of carbon dioxide is present. Since this proportion of carbon dioxide is present in the internal accessory organs of aerial respiration of the fishes, and since, with few exceptions such as the skin of the eel, all the aerial accessory respiratory organs of the fishes are internal, this type of blood would be unsuitable for any fish which was evolving an accessory organ of aerial respiration. Blood of this type need not therefore be considered in discussing the ease with which fishes can pass from aquatic to aerial respiration.

This type of blood must also be unsuitable for animals living in the water of tropical swamps, which contains much free carbon dioxide. It has been suggested in a paper previously given before the Society ('Proceedings,' April 18, 1929) that fishes have evolved aerial respiration in such waters in response to the lack of dissolved oxygen which occurs in them. It seems that the evolution of a blood less sensitive to carbon dioxide, and more similar to that of the terrestrial vertebrates, was necessary for life in these swamps and was also a necessary preliminary to the evolution of organs of aerial respiration. It was also suggested in the previous paper that the aerial respiration so acquired made the change to amphibian life more easy for the evolving vertebrate. It has thus appeared that the modification of the blood was an earlier change in the series which made possible the migration of the vertebrate from the water to the land: and, further, that this series of changes occurred not at the same time, but serially, each in response to the conditions in which the animal was living at the time at which the change took place.

It is also pointed out that environments in which these changes might arise occur to-day only in regions to which the tide does not reach. It is therefore suggested that the absence of the tide in fresh waters has been the most important factor in producing the more frequent migration of animals on to the land from their margins than from those of the sea. In past geological times, when the differences in salinity may have been less, this feature would have differentiated the various types of littoral as markedly as it does to-day.

Dr. W. T. Calman, while agreeing that invertebrates such as Crustacea seem to be able to pass more easily from aquatic to aerial respiration, pointed out that modifications of structure such as inflation of the gill-chamber did occur among crabs. He also stated that many crabs had come to land directly from the sea, and suggested that the sea-beach, alternately covered and laid bare by the tides, was in some respects a favourable environment for animals in a transitional state.

Dr. C. Tate Regan said that he thought many littoral fishes became air-breathers when the tide was out, but had no special structural modifications in relation to this habit. He gave as an example a blenny sent to him from Devonshire in a match-box, which was quite lively when received the next morning. He remarked that one of the most important steps in the evolution of man was taken when certain air-breathing fresh-water fishes of the order Rhipidistia came out on the land, probably in Devonian times, and gave rise to the earliest four-footed vertebrates.

Dr. Carter replied that he accepted both points mentioned by Dr. Calman and instanced land Nemertines and the Amphipods as animals which have been thought to have a direct marine origin. He remarked that some fishes, *Symbranchus* and *Hypopomus*, which have gills apparently of the most extreme type in point of adaptation to aquatic respiration, were able to respire by filling the gill-chamber with air. It also seemed to him that it was variations of long period in an environment which were important in stimulating evolution, and that these seemed to him to occur more frequently where there was no tide.

14th May, 1931.

Sir Sidney F. Harmer, K.B.E., F.R.S., President, in the Chair.

Previous to opening the business of the meeting, the President called on Sir Arthur W. Hill to read a cablegram just received from New Zealand, stating that our Fellow, Dr. Leonard Cockayne, C.M.G., F.R.S., recently threatened with blindness, had had a successful operation and that it was hoped that he would in time completely recover his sight.

The Proceedings of the previous Meeting, held on Thursday, the 30th April, having been circulated, were taken as read and confirmed.

A list of names of those who had made gifts to the Library since the previous meeting was read and laid on the table.

The following Fellows signed the Obligation in the Book of the Charter and Bye-laws and were admitted :—Henry Rissik Marshall, Percy James Greenway, David Guthrie Catcheside, and Ben Dawes.

A certificate of recommendation to Fellowship in favour of Rachel Elizabeth Harries was read for the second time.

The following Candidates were balloted for and elected as Fellows :—John Edward Senaratna, Lt.-Col. Leonard Charles Rudolph Messel, M.A., O.B.E., T.D., Alfred Samuel George Mardon, Eric Lomax Crossley, B.Sc., Capt. Cyril Diver, Miss Marjorie Alison Westbrook, M.Sc., Joseph Davenport Snowden, Clifford Gerald Hansford, M.A., Thomas Leonard Lancaster, M.Sc., Maurice Burton, M.Sc., Sidney Phippen Heath, M.A., Narendranath Mitra, Herbert Ashby, Edred John Henry Corner, M.A.

The following Candidates were balloted for and elected as Foreign Members :—Professor Carl Erich Correns, Professor Friedrich A. F. C. Went, Professor Ludwig Diels, Dr. Carl Christensen.

Miss R. F. Shove exhibited a dwarf wych-elm tree, 21 years old, grown in a flower-pot from a seed of 1909. Mr. Wilmott, the President, and Sir Arthur W. Hill agreed in the interest of the exhibit, for which the thanks of the Meeting were warmly accorded.

Mr. A. J. Wilmott gave a lantern-lecture entitled "A Botanical Tour in Spain."

The President expressed the thanks of the Meeting for this interesting communication.

The Physiology of Variation.

By Mr. C. F. A. Pantin (Visitor).

The adaptation of organisms to their environment has long been recognized. But whereas adaptation of form has been subject to precise description, the problem of functional adaptation has not yet been fully considered. Physiological characters often have an adaptational significance attached to them on insufficient evidence. As an example, animals which live in oxygen-deficient environments develop the pigment hæmoglobin. We know that hæmoglobin readily combines with oxygen, and, taking these considerations together, we infer that the hæmoglobin is developed as an adaptation to conditions of oxygen-deficiency. There is great danger in this kind of argument unless the hypotheses of adaptation are immediately tested in the field and in the laboratory. Both *Planorbis* and *Arenicola* live under conditions of oxygen-deficiency, but the function of their hæmoglobin is not the same. In *Planorbis* it simply conveys oxygen from the external medium to the tissues. In *Arenicola* it acts as a store of oxygen during periodic complete anærobiosis. To rest content with the mere assertion of adaptation may cause us to miss the true functional significance of the character.

Provided experimental study follows, hypotheses of functional significance can be very helpful in elucidating the relation of organism and environment. The so-called "optimum" temperatures for the digestive actions of the enzymes of many invertebrates were found to be far above the normal temperature at which the organisms live. A search for an adaptational significance for this showed that the discrepancy arose from the brief duration of laboratory experiments. If the enzymes were allowed to act for the same length of time as food remained in the gut a much lower "optimum" was found, which corresponded to the normal temperature at which the animal lived.

The chief difficulty in considering physiological adaptation rests in the heterogeneous things classed under "Physiological Characters." These include such different things as:— (1) Structures, such as the hæmoglobin molecule, (2) Processes of Metabolism, (3) States maintained by the organism, such as the ionic composition of the blood, (4) Properties of the organism as a whole, such as the limits of temperature and *p*H within which it will survive.

Molecular structure is of special interest. Work on immunity shows that it is capable of specific gradation of the same order as gross morphological structure. But we know that even such molecules as protein are not infinitely plastic. Consideration of the numbers of amino-acids known and of the size of the protein molecule indicates that a definite number of kinds of protein molecule are possible. Approximately this is the immense number 10^{3000}. This would give almost innumerable gradations in properties of the proteins; but the fact must be remembered that each gradation can only be effected by a definite step.

This limitation is seen more clearly in the case of respiratory pigments. Only four kinds are found in the animal kingdom (hæmoglobin, chlorocruorin, hæmerythrin, and hæmocyanin). These make their appearance repeatedly in entirely unrelated organisms. The gradual evolution of a specialized molecule like hæmoglobin is impossible: it could only arise by some process analogous to mutation. Recent work has shown that there normally exist in all protoplasm hæmatin compounds, such as those derivable from cytochrome, which could easily be converted into hæmoglobin.

It thus appears that if an organism develops a respiratory pigment it is strictly limited in the materials at its disposal for its construction. In the development of a relatively simple structure such as a hæmoglobin molecule this results in the independent appearance in different organisms of precisely the same structure, and these structures cannot be gradually evolved. Complex structures such as protein

molecules and even morphological structures are severely limited in the same way by the materials at the disposal of the organism out of which they can be constructed. Immense numbers of gradations may be possible in complex structures, but variation in these must ultimately occur by discontinuous changes analogous to the change of hæmatin compounds into hæmoglobin, though the resulting change in physical properties may be much less profound than that which occurs in this particular case.

The other things classified as physiological characters are complex, and with them it is even more necessary to avoid facile ascription of functional adaptation without any experimental test.

The study of physiological adaptation shows how vitally necessary is the accurate description of the structure of the organism combined with accurate description of its physiological relation to the environment.

Dr. E. J. Allen thought that Mr. Pantin's communication was one of great importance, as being perhaps the most successful attempt yet made to explain to the general biologist the bearing of recent researches in comparative experimental physiology on the problems of variation, adaptation, and evolution, and on other problems in which he is interested.

Dr. G. P. Bidder asked if Mr. Pantin could explain why only such a small number of molecular variations are possible? To one ignorant of chemistry, it would seem that a large part of organic substances consists of chain-molecules of linked atomic groups, which in zoological language show metameric repetition, a large number of the middle segments being often similar. Why is there not as nearly infinite a possibility of variation as there is, among tangible things, in metameric worms and arthropods? Why cannot atomic appendages link themselves to this or to that segment of the molecule, varying in length, character, and position on the chain, with arithmetical possibilities of permutation comparable to those of the morphological arthropod appendages?

Mr. J. Ramsbottom said that he had been particularly pleased with Mr. Pantin's suggestion that physiological characters might be useless. For himself he had long been forced to the opinion that plants were often able to produce enzymes which would never be called into play or could withstand extreme conditions which they would never have to face in normal circumstances.

The President expressed the thanks of the Society to Mr. Pantin. He commented on the fact that a physiological character may be very permanent in nature or sporadic in its occurrence. The first alternative is illustrated by the recent

investigation by Prof. W. J. Dakin (Proc. Zool. Soc. 1931, p. 11), who has shown that the osmotic concentration of the blood gives clear evidence of the affinity of the Holocephali to the Elasmobranchii and of the Dipnoi to the higher Vertebrates. In the second alternative, hæmoglobin is found to be possessed by certain species of groups in which it does not normally occur. The suggestion that hæmoglobin may be used as a storage reservoir for oxygen indicates the interesting results which would probably be obtained by making a physiological investigation, if that were possible, of the Cetacea. The muscles in this group are brilliantly red and appear to contain a specially large amount of hæmoglobin: and the blood is believed to be present in larger relative quantity than in any other Mammals. These facts are no doubt correlated with the prolonged immersion of the Cetacea when sounding.

Mr. Pantin in reply said that Dr. Bidder had raised an important point. Mr. Pantin had not wished to give the impression that the number of possible molecular structures was small: it was, in fact, inconceivably great. At the same time it was limited in that a progressive change in molecular structure could not be gradually brought about by infinitely small changes. In a simple case such as the development of a respiratory pigment, there were no gradations between the precursor hæmatin compounds and the fully developed hæmoglobin molecule which alone had the right properties. In more complex cases there might be many intermediate gradations, but there must be a discontinuous jump in passing from each gradation to the next. Replying to the President's statement about the very rich hæmoglobin supply of the whale both in the blood and in the muscle, it seemed highly probable that this is of adaptational significance.

28th May, 1931.

Sir Sidney F. Harmer, K.B.E., F.R.S., President, in the Chair.

The Proceedings of the previous meeting, held on Thursday, the 14th May, 1931, having been circulated, were taken as read and confirmed.

A list of names of those who had made gifts to the Library since the previous meeting was read and laid on the table.

The following Fellows signed the Obligation in the Book of the Charter and Bye-laws and were admitted:—Marjorie Alison Westbrook, Cyril Diver, and Herbert Ashby.

Certificates of recommendation of the following candidates for Fellowship were read :—For the second time, in favour of Percival Sydney Jewell and Guy Coburn Robson.

The following candidate was balloted for and elected a Fellow :—Rachel Elizabeth Harries.

The Treasurer presented his Financial Report and the Accounts of the Society, duly audited, for the year 1930–31. On a motion by Mr. James Groves, seconded by Mr. G. R. de Beer, the Report and Statement of Accounts were adopted.

The Bye-Laws regulating the Election of Council and Officers having been read by the Assistant Secretary, the PRESIDENT declared the Ballot for Council and Officers to be open, and voting began. The ballot for Council was closed at 5.30 P.M. and for Officers at 6.0 P.M.

Meanwhile, the Librarian and Assistant-Secretary presented his Report as follows :—

Since the last Anniversary Meeting the Society has lost fifty-two members. The detailed account is as follows :—

20 Fellows by Death:—George Henry Adcock, Thomas Fulton Bourdillon, Robert Moir Clark, Edward A. Fitz-Gerald, W. Catton Grasby, Arthur Stanley Hirst, John Hodgkin, Edward Morell Holmes, Frederick Lewis, James MacDonald, W. Carmichael M'Intosh, Edward John Miers, Horace Woollaston Monckton, Spencer Le Marchant Moore, Charles Edward Moss, Richard Vowell Sherring, Herbert Sutcliffe, Thomas Wibberley, Bernard Barham Woodward, and Richard Cranfield Wren.

5 Foreign Members:—Louis Dollo, Heinrich Gustav Adolf Engler, Serge Gabrilowitch Navashin, Carl Hansen Ostenfeld, and Ignaz Urban.

15 Fellows by Withdrawal:—Edith Bolton, Leonard Alfred Boodle, George Norman Bunyard, Bertram Henry Buxton, William John Dakin, Harold Downes, George Forrest, Walter Wilson Froggatt, Alfred G. Howard, Ernest Victor Laing, Percy Hutchinson Lamb, Charles Francis Ullathorne Meek, Percy Amaury Talbot, Richard Waterfield, and Cyril Tenison White,

15 Fellows by Removal:—Eustace Cecil Barton-Wright, Walton Henry Charter, Bernard Cuthbert Ellison, Frank Norman Howes, John Robert Lewis Kingon, Samuel Lyon, Hugh Fraser Macmillan, Richard Mounsey, Pheroshaw Jamsetjee Panday, Amrit Bhimrao Punde, Edith Philip Smith, and Albert Denny Usher.

During the Session 4 Foreign Members and 34 Fellows have been elected, including the election at the Anniversary Meeting. Of the 34 Fellows, 24 have qualified.

During the year, 46 works have been purchased and 181 books and pamphlets presented, making a total of 227 additions to the Library. This number does not include current periodicals, of which the Society receives between 600 and 700.

At the conclusion of the Assistant-Secretary's report, the PRESIDENT appointed Mr. James Groves, Mr. A. W. Sheppard, and Mr. B. H. Soulsby as Scrutineers of the Ballot.

In handing the Linnean Gold Medal to Dr. THEODOR AUER, Secretary to the German Legation, for transmission to Professor KARL Ritter von GOEBEL, the PRESIDENT gave the following account of Professor von Goebel's great services to Botany :—

In presenting the Linnean Medal to Professor Karl Ritter von Goebel the Council of the Linnean Society has had in mind his long and important services to the advancement of botanical science. His inaugural dissertation was on the development of the prothallus of *Gymnogramme leptophylla* in 1877 ; and during the fifty-four years since then there has been a steady flow of important contributions to our knowledge of plants, up to and including the present year.

The stage which Botany had reached when Professor von Goebel began his work is realized to some extent when we remember that Wilhelm Hofmeister died in 1877 at the early age of 53—in fact, Professor von Goebel is the last surviving pupil of that great botanist.

Very soon after gaining his doctorate Professor von Goebel began to take a leading part in the botanical activities of that day—activities which revolutionized the study and the teaching of botany ; in this he was associated with de Bary at Strassburg and Sachs at Würzburg. His researches covered a wide field and in his work on the comparative development of sporangia in 1881 he formulated the conception of the sporangium *sui generis* which is always associated with his name, and which led to the elucidation of homologies.

When in 1882 it was decided to produce a new edition of Sachs's Textbook of Botany which had first appeared in 1868 and had rapidly reached a fourth edition, von Goebel was entrusted with the part which was later translated and published as " Outlines of Classification and Special Morphology of Plants." This had a great influence on the teaching of botany in this country, as it attempted to carry out a terminology resting on homology as established in development. That Karl von Goebel already had an established position in the opinion of British botanists is seen from the fact that he contributed the article on Muscineæ to the ninth edition of the ' Encyclopædia Britannica ' (1884). The same year he wrote a volume in Schenck's ' Handbuch der Botanik ' with the title ' Vergleichende Entwicklungsgeschichte der Pflanzenorgane ' which may be regarded as the forerunner of his ' Organography of Plants,' a work first published in 1898-1903 and translated in 1900–1905 :—a third edition was completed last year.

More to Professor von Goebel than to any other botanist do we owe the change in the teaching of morphology from the idealistic morphology which regarded the configuration exhibited by plants as a hypothetical construction, to considering it as a part of their life-phenomena determining in what degree the

formation of organs shows an adaptation to external relations. The ' Organography of Plants, especially of the Archegoniatæ and Spermaphyta ' is a work which, even as a compilation, would have assured the author a prominent position among botanists ; but the amount of original work included in it and the general co-ordination mark it as one of the classics of botanical literature. In addition to numerous developmental studies of Archegoniatæ, Professor von Goebel has covered a wide field in general botany, including fungi, sea-weeds, and lichens. His investigations on biology and on plant vegetation, mainly the results of travel abroad, are, however, more important ; the best-known series is the ' Pflanzenbiologische Schilderungen,' which appeared from 1889 to 1893.

It is not possible to enumerate more details of a botanical life so rich in results,but mention may be made of two additional books, ' Die Einleitung in der Experimentelle Morphologie der Pflanzen ' (1908) and the memorial volume published in translation by the Ray Society in 1926 ' Wilhelm Hofmeister : the Work and Life of a 19th Century Botanist.'

While so actively engaged in research and in teaching, Professor von Goebel has occupied the arduous position of Editor of the botanical periodical ' Flora ' from 1889.

Professor von Goebel was elected a Foreign Member of the Linnean Society in 1892, and is thus our oldest Foreign Member. In handing to you this gold medal, the highest award of our Society, I ask you to convey it to him with our best wishes for continued good health and enjoyment in the science which he has done so much to promote.

In reply, Dr. Auer made an acknowledgment on behalf of Professor von Goebel.

In the introductory passage to his Address the PRESIDENT made the following statements :—

" The retirement of Dr. G. P. Bidder from the office of Zoological Secretary is an event we shall all regret. It will be generally agreed that his own communications, as well as his contributions to our discussions, have been most stimulating. I am sure you will desire me to give him the thanks of the Society for his valuable services, and to wish him an improvement in his health when relieved from the cares of the office he has held since 1928.

" The final instalment of the sum of £2,000 due to the Society from the Carnegie United Kingdom Trustees has now been paid. The assistance thus given has been invaluable, and it has resulted in the enrichment of the Library by a large number of purchases which could not have been made out of ordinary income.

"The apartments on the top floor formerly occupied as a residence by Colonel Gage have been considerably altered, mainly with the object of providing additional space for the library. This was a matter of special importance at a time when large additions have been coming in, principally as the result of the substantial donation of the Carnegie Trustees, and partly owing to the receipt of a portion of the B. B. Woodward Bequest referred to below.

"By the terms of the Will of Mrs. Jane Jackson, widow of the late Dr. Benjamin Daydon Jackson, who had been Secretary to the Society for 46 years, the Linnean Society is made residuary Legatee, subject to three life-interests, of property expected to be of the value of about £4,000. The money is to be applied for the purpose of increasing the remuneration of the staff. This bequest will perpetuate the memory of an officer who had done excellent work for the Society.

"An important alteration has been made in the mode of publishing the 'Proceedings,' which had previously been issued in one part, annually, after the completion of the Session. Owing to the difficulty of obtaining the necessary material, and particularly the Obituary Notices of members of the Society who had died during the Session ending with the Anniversary Meeting in May, it had not been found possible to publish the 'Proceedings' much before the end of the Calendar Year. The 'Proceedings' are now being issued in sheets of 16 pages, published separately as soon as they are ready—a method which makes it possible to publish notices of communications shortly after they have been read. This acceleration will, no doubt, be appreciated by authors. Since the Society is interested in the whole range of Biology, the circulation of its 'Proceedings' is considerably larger than that of many journals which are concerned solely with Zoology or Botany or with a special branch of either of these sciences.

"Obituary Notices of members who died during the past Session will appear in the 'Proceedings,' but the following should be particularly mentioned. It will be seen that the Society has lost an exceptionally large number of eminent Foreign Members.

"Mr. H. W. Monckton, who had held the office of Treasurer for more than twenty-five years. At the General Meeting on January 22nd the Society recorded their gratitude for his great services, and we all mourn the loss of a colleague for whom we had the highest esteem. One of the latest matters in which Mr. Monckton had been particularly interested was the re-arrangement of the rooms upstairs. The practice of holding the Meetings of the Council in one of these rooms, thus making the Eastern Library available for use as a tea-room before the General Meetings, was entirely his idea and was carried

through by him. I believe the change to be one which has received the general approval of the Society.

" Professor W. C. M'Intosh, F.R.S., Linnean Medallist, 1924, had been a Fellow for the exceptionally long period of 68 years, and he was the oldest British Zoologist. He maintained his active interest in his subject to the last, and there are many of us who counted him as a valued friend.

" Mr. Spencer Le M. Moore, who became a Fellow in 1875, a leading systematist, distinguished for his work on the Floras of Brazil and Western Australia.

" Mr. E. M. Holmes, also elected a Fellow in 1875, for many years Curator of the Pharmaceutical Society's Museum, formerly prominent as an Algologist.

" Mr. B. B. Woodward, who did admirable work as Librarian of the British Museum (Natural History), bequeathed to the Society his valuable collection of books and papers on the Mollusca. The Bequest is to take effect on the expiry of the life-interest of Mr. A. S. Kennard, who has kindly waived some of his rights by transferring to the Society a substantial part of the Bequest dealing with the marine Mollusca.

" Mr. R. V. Sherring, who made extensive collections of ferns in the West Indies.

" Mr. C. E. Moss, Professor of Botany at Johannesburg since 1917, one of the pioneer workers in Ecology and a prominent systematist.

" Professor H. G. A. Engler, the oldest Foreign Member on our list, having been elected in 1888, Linnean Medallist, 1913, pre-eminent as a systematist, plant geographer, and administrator.

" Professor I. Urban, Foreign Member, 1901, for many years Professor Engler's second in command at Dahlem, and himself a foremost systematist.

" Professor S. G. Navashin, Foreign Member, 1911, known chiefly for his researches on fertilisation.

" Professor L. Dollo, Foreign Member, 1920, distinguished for his researches on *Iguanodon* and for his discussions of questions of evolutionary interest.

" Professor C. H. Ostenfeld, Foreign Member, 1929, prominent as a systematic botanist and plant geographer."

The PRESIDENT then delivered his Address, " Recent Work on Polyzoa."

On its conclusion, Mr. T. B. BLOW moved " That the President be thanked for his excellent Address, and that he be requested to allow it to be printed and circulated amongst the Fellows." The motion was seconded by Dr. A. B. RENDLE, F.R.S., and being put to the Meeting was carried with acclamation.

The Scrutineers of the Ballot, who had retired at the appointed times with the voting-lists for the election of the Council and of the Officers, having completed their scrutiny, reported to the President, and he declared the result as follows :—

Council for 1931–32.—Dr. G. P. Bidder ; Mr. I. H. Burkill ; Dr. W. T. Calman, F.R.S. ; Dr. G. S. Cater ; Major T. F. Chipp, M.C. ; Mr. G. R. de Beer ; Mr. Francis Druce ; Dr. Philippa C. Esdaile ; Professor R. R. Gates, F.R.S. ; Sir Sidney F. Harmer, K.B.E., F.R.S. ; Professor T. G. Hill ; Professor H. S. Holden ; Mr. G. W. E. Loder ; Professor J. R. Matthews ; Mr. J. R. Norman ; Mr. John Ramsbottom, O.B.E. ; Lt.-Col. J. Stephenson, C.I.E., F.R.S. ; Miss E. M. Wakefield ; Professor F. E. Weiss, F.R.S. ; Mr. A. J. Wilmott.

(The retiring Councillors were Dr. E. J. Butler, C.I.E., F.R.S., Dr. E. J. Collins, Professor W. T. Gordon, Miss G. Lister, and Dr. C. Tate Regan, F.R.S.)

Officers for 1931 32.—*President* : Professor Frederick Ernest Weiss, F.R.S. ; *Treasurer* : Mr. Francis Druce ; *Botanical Secretary* : Mr. John Ramsbottom, O.B.E. ; *Zoological Secretary* : Lt.-Col. John Stephenson, C.I.E., F.R.S.

Before declaring the Session of 1930–31 closed, the President expressed his thanks to the Fellows.

PRESIDENTIAL ADDRESS.

By Sir Sidney F. Harmer, K.B.E., Sc.D., F.R.S., P.L.S.

RECENT WORK ON POLYZOA.

(With 6 Text-figures.)

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I. Introduction.

In my Presidential Address of 1929 I discussed certain points connected with the study of the Polyzoa. The excellent work which has been done during the last few years on the relation of these animals to their surroundings justifies me in returning to this subject. Some of it has a distinct bearing on variation and specific characters, and other parts indicate that the old conception of Zoophytes—organisms intermediate between animals and plants—was not altogether meaningless, if these creatures are considered in relation to their mode of growth rather than from a morphological point of view.

Issued September 7th.]

II. The original Drawings of John Ellis.

My 1929 Address included a discussion of the part taken by John Ellis in establishing the animal nature of Zoophytes. It produced a letter from my friend Professor F. J. Cole, F.R.S., informing me that he had recently found many of the original drawings made by Ellis himself, or prepared for him by his artists. Although some of the facts thus revealed are on record in an early volume (1860) of the 'Catalogue of the Museum of the Royal College of Surgeons of England,' they appear to have been completely forgotten. With the kind permission of Sir Arthur Keith, F.R.S., Conservator of this Museum, and with the valuable assistance of Mr. W. Le Fanu, the Librarian, I have been able to make a thorough examination of these drawings, which are carefully preserved in the Museum in Lincoln's Inn Fields.

The drawings had been mounted in a large volume marked "Hunterian Drawings, I. (S)." On folio 11 there is a MS. note, signed "W. Clift, June 16, 1830," as follows :—

"*Ellis's Original Drawings of Zoophytes.*

"Mr. Hunter purchased a great number of the original Drawings of Ellis's Corals and Corallines now in the Collection . . . together with many small specimens of Corallines &c., with Letters and Memoranda respecting them . . . *probably at Mr. Ellis's Sale* :—and probably many of the larger specimens of Corals etc. which have now no history or reference. It is also probable that many of the specimens of Corallines in Spirit were formerly in the possession of Mr. Ellis, *as well as* the large Specimen of Siren lacertina now in the Hunterian Collection . . . as it is evidently the identical Specimen described and figured by John Ellis, Esq., in the Philos. Transact."

The folios which immediately follow this note include an almost complete set of the original drawings for the plates in the 'Natural History of Zoophytes' (1786) by Ellis and Solander, and of those for the 'Essay towards a Natural History of the Corallines' (1755) by Ellis. It seems probable that some of the plates (particularly in Ellis and Solander's work) which are not represented by drawings were prepared by the artists from actual specimens.

Many of the drawings, by Ehret and other artists, are of conspicuous beauty. Most of the originals have been reversed in reproduction, a fact which is unimportant, except in the case of the Gasteropod, represented as a sinistral shell in pl. xxxiii of Ellis (1755), really drawn as a normal dextral specimen.

The artists' work has been very faithfully reproduced in the published volumes. I was interested to find that, in practically

all cases, the polypes shown in various plates of Ellis (1755) are not represented in these drawings. They were obviously added at the last moment, when the figures had been arranged for reproduction, or perhaps after the plates had been practically completed.

On p. viii of his "Introduction" Ellis referred to a visit he had made to Brighthelmstone (Brighton), in June 1754, in company with Mr. Ehret. I am able to exhibit the most important result of this visit by a photograph which was taken by Professor Cole from the original on folio 52 of the Hunterian volume. It is one of the few sets of drawings in which a locality is given, but it is most fortunately inscribed "Urtica Marina" and "Brighthelmstone, June 1754." The "Urtica Marina" is a very obvious Campanularian Hydroid and it appears to be the species represented in pl. xii, fig. C of the 'Essay.' Ellis stated, on p. ix, that he had observed the polypes represented in this particular figure during the visit to Brighthelmstone, although the drawing is not the one from which this part of the plate was reproduced. He referred to this Hydroid, on p. 21 (no. 18), under the name of the "Sea-thread Coralline," which is the *Sertularia dichotoma* (pars) of Linnæus, 1758. Hincks (1868, p. 181) quotes fig. C as an illustration of *Gonothyræa loveni* Allman. The determination of the species is comparatively unimportant, as the drawings are of interest mainly because they show what was almost the first step in the great discovery, by Ellis, of the animal nature of Hydroid Zoophytes. The drawings are so clear and convincing that we need have no surprise that a naturalist so competent and accurate as Ellis should from the first have had no doubt that the generalization which he established by his later observations was correct.

The back of folio 50 of the same album bears a drawing of a Sertularian Hydroid with protruded tentacles. This is fig. A of pl. v of the 'Essay,' also mentioned (p. 10) as having been observed with polypes at Brighthelmstone; and it is the "Sea-Oak Coralline," *Sertularia pumila* of Linnæus and later authors. There is a third set of drawings, on folio 53, which roughly indicate some of the figures of pl. xxxviii of the 'Essay.' Among these drawings, A, B–R, and O–P of the published plate are recognizable, and all show expanded polypes. "A" was referred by Hincks (1868, p. 235) to *Sertularella polyzonias* (L)., and "B" (p. 181) to *Gonothyræa loveni* Allm. "O–P" represent one of the Polyzoa, the "Paper Moss" of Ellis, *Flustra papyracea* Ell. & Sol. The photographs shown of these drawings were also taken by Prof. Cole.

The specimens of Zoophytes, apparently from the collection of Ellis, which are preserved in the Museum of the Royal College

of Surgeons, are disappointing, consisting mostly of small dry fragments in poor condition. It does not seem to me that they are comparable in value with the published drawings of the 'Essay,' which, as I stated in my Address (1930, p. 84), should, in my opinion, be considered the types of the respective species.

It may be of interest to add that an important set of the Madreporarian Corals which were described by Ellis and Solander (1786) are preserved in the Hunterian Museum at Glasgow, and that lists of them have been published by J. Young † and J. Graham Kerr ‡.

III. Studies on living Polyzoa.

Until the last few years information with regard to many essential points in the biology of the Polyzoa was remarkably vague. The freshwater forms were the best known in this respect, since it was at least recognized that the annual recurrence of winter, in temperate latitudes, usually puts an end to the life of the colonies. But with regard to the vast majority of the marine forms the details of the life-cycle are still unknown. Among recent writers whose results I propose to notice I must specially mention Professor Ernst Marcus, whose admirable studies (1925–1930) have elucidated many points which had previously been obscure. He has, moreover, collected the facts germane to his subject from a variety of sources, so that his memoirs form a most interesting summary of the present state of our knowledge.

A. *Phylactolæmata.*

(i) *Occurrence, Culture in Aquaria, etc.*—The Phylactolæmata constitute a small group, with few genera and species, and they are confined to fresh water, but two or three genera of the Gymnolæmata may also be found in the same habitat. The Phylactolæmata (with the exception of *Fredericella*) are readily recognized by the fact that the lophophore, the part of the body from which the tentacles arise, has the shape of a horse-shoe, that of the Gymnolæmata being circular.

The culture of freshwater Polyzoa in aquaria requires special precautions. Marcus (1925, 1926[3]) has given useful information on this subject. Success in keeping them alive depends largely on the provision of an ample supply of food, which consists of Diatoms, Desmids, Protozoa, and other microscopic food. Marcus obtained the best results with the aid of cultures of Protozoa—*Euglena*, *Colpoda* and *Chlamydomonas*

† Young, J., 1877, Ann. Mag. Nat. Hist. (4) xix, 116.
‡ Kerr, J. G., 1910, 'Glasgow Naturalist,' ii, 111.

being specially recommended (1926[3], p. 281). It is further essential to exclude the numerous predatory animals which attack them, including Gasteropods, insect larvæ, Triclad Planarians, Oligochæte worms, and small Crustacea and Arachnids.

Fredericella is exceptional in possessing a circular lophophore, on which account it has often been described as a connecting-link between the two main groups. Marcus (1926[3], p. 286), following other authorities, points out that this apparent simplicity is deceptive, since, in the young buds, the lophophore shows distinct indications that it is constructed on the usual Phylactolæmatous plan. The genus does not appear to be specially primitive either in its structure or in its embryology ; and the belief that it represents anything like the ancestral characters of the group rests on an insecure foundation. Like the majority of the forms of *Plumatella*, it has a delicate branching habit. At the opposite end of the series is *Pectinatella*, in which the separate colonies become aggregated into large masses, which may reach a length of 2 metres (Oka, 1891, p. 90). The greater part of these masses is formed by the common secretion, by all the colonies, of a basal layer of gelatinous material, which is a modification of the chitinous cuticle of most of the other genera, and reaches a thickness of several centimetres.

Pectinatella magnifica had for some years been found solely in the United States. In 1883 it was discovered by Kraepelin near Hamburg, and since that date it has been regularly found in various parts of Germany, and more recently in Bohemia. This remarkable distribution has usually been explained by the assumption of an accidental introduction into Germany from America. Borg (1930, p. 125) has expressed the opinion that the genus may be cosmopolitan, a conclusion which seems to me improbable, in view of the absence of records from the British Isles.

(ii) *Locomotion of the Colonies.*—The colonies of Polyzoa are almost invariably fixed, but exceptions to this rule are found among the Phylactolæmata. The young colony which escapes from a statoblast (see p. 119) is ciliated externally, and even in *Plumatella*, which is not locomotive in the adult condition, it is capable of moving to a better place if its first attempt at fixation has proved unsatisfactory (Marcus, 1925, p. 22). The same thing may happen in *Lophopus* or *Cristatella*, but in both these genera the adult colonies also can move from place to place. The rate of movement is slow :—1–2 mm. an hour in young colonies of *Cristatella* (Marcus, 1926[3], p. 319).

Young colonies of *Lophopus* can easily be induced to move

from a position where the illumination is too strong to a darker place. The want of food (in aquarium cultures) induces division of the colonies, and the small pieces thus produced move more readily than the others (Marcus, 1926[3], p. 290). The method of locomotion has been the subject of controversy, but Marcus (p. 319) comes to the conclusion, on experimental evidence, that the movement of *Cristatella* is mainly the result of the contractions of the muscles of the body-wall, especially of those of the sole of the colony, and that it is rendered possible by the gelatinous or even semi-fluid character of the basal ectocyst or cuticle. He shows conclusively that movement is not produced, as had been supposed, by the contraction of the retractor muscles of the polypides.

(iii) *Statoblasts*.—The Phylactolæmata possess two, or even three, distinct methods of reproduction—by eggs and by the remarkable "statoblasts," regarded as internal buds. The statoblast is covered by a chitinous investment, which protects it when it is set free on the death of the parent colony. It usually possesses a wide equatorial ring of chitinous cells containing gas, so that it floats to the surface on being liberated. Statoblasts of this type do not occur in *Fredericella*. In *Plumatella*, in addition to the floating statoblasts, there is a second form, which does not possess the annulus of gas-containing cells, and accordingly does not float. These "sessile" statoblasts, which are the only ones found in *Fredericella*, are usually produced in such a position that on the dissolution of the parent tubes they remain attached to the substratum on which the colony was growing. Owing to their possession of a highly developed shell, the statoblasts of both kinds are specially adapted to withstand unfavourable conditions. The floating statoblasts are carried by the currents of the water, and, as they are at the surface, they are no doubt affected by the action of the wind. They are obviously a means of distributing the species within the area of fresh water in which they have been produced. Statoblasts have occasionally been found in the mud adhering to water-birds, and it can hardly be doubted that this is one of the facts which explain the almost cosmopolitan distribution of certain genera or even species of Phylactolæmata. It is noteworthy that the Gymnolæmata which occur in fresh water develop hibernacula, not homologous with statoblasts, but playing the same part in the general economy of the species.

The above facts have long been known, but Marcus has brought together others, to which he has added by his own experimental work; so that it is now possible to obtain at least a general idea of the inter-relations of the several forms of reproductive bodies in Phylactolæmata.

The statoblasts produced in autumn require a period of rest before they can germinate. This may be given by their inclusion in ice during the winter, but the absence of oxygen, as in the case of statoblasts which have been buried deeply in mud, can be equally effective. These statements, which depend on experiments by Braem (1890, p. 82), do not, however, completely explain the facts, since autumn statoblasts which have been brought into an aquarium before the occurrence of frost, and kept there during the winter months, have been found to germinate normally in the ensuing spring. Wesenberg-Lund (see Marcus, 1925, p. 23) placed summer statoblasts in an ice-cellar, and found that 80 per cent. of them germinated at a temperature of 22° C., after fifteen months in these wintry conditions. Statoblasts have been shown, moreover, to be capable of germinating after being kept dry for some time in air. These conditions, whether inclusion in ice or drying in the summer or other seasons, are found in Nature.

Germination of the statoblasts does not take place at a temperature below 9° C. (Marcus, 1925, p. 22). The shell splits equatorially, and a young, externally ciliated colony emerges, with one or more polypides visible at birth. The colony produced in spring from an autumn statoblast usually produces reproductive organs, ovaries and testes, early in the year. In *Fredericella*, Kraepelin found that these spring colonies develop no statoblasts. Their larvæ, which have grown from eggs, give rise to colonies which in their turn produce statoblasts destined to survive the next winter. In this case it is possible to speak of an alternation of generations. But alternation seems not to have been definitely established, even in this genus, since Braem found a colony of *Fredericella* in which both gonads and statoblasts were present. In *Plumatella*, also, the spring colonies may produce statoblasts in addition to the eggs which give rise to larvæ. The sexual period usually lasts from three to four weeks, and in *Plumatella fungosa* it begins at about the middle of May. This species seems to be exceptional in sometimes producing a second brood of larvæ in the late summer (Marcus, 1926[3], p. 296). There is some evidence, from observations by Wesenberg-Lund, in Denmark, that in high latitudes the colonies may reproduce solely by statoblasts (Marcus, 1925, p. 30).

(iv) *Larvæ developed from Eggs.*—Although the larvæ of marine Polyzoa have characters which appear to connect them with the Trochosphere larvæ of other Phyla, those of the Phylactolæmata are so modified that at birth they are young colonies which swim by means of a continuous investment of cilia. They are already provided with at least one functional polypide (*Fredericella*) when they are hatched, but

in *Cristatella* there are at this time from two to twenty-five polypides or polypide-buds. The free life is short, probably not exceeding 24 hours (Marcus, 1926[1], p. 87).

The reactions of the larvæ to external conditions are no doubt due to the presence in the ectoderm of a nerve-plexus, connected with sense-cells which are most abundant at the pole by which fixation is ultimately effected. The birth of the larva and its subsequent behaviour have been described by Marcus (1926[1]; 1926[3], p. 297). His experiments led him to the conclusion that, immediately after birth, it ascends to the surface—a fact which is of importance in connection with the distribution of the species by currents. Its choice of a spot for fixation is affected by the intensity of the light. In one experiment (1926[3], p. 303, no. iii) in which 100 larvæ were placed in a vessel half covered by black paper, 92 fixed normally, and 83·7 per cent. of these attached themselves in the shaded part. In another interesting experiment, the water at the surface of a vessel was heated by an electric lamp, and ten thermometers were arranged in series with their bulbs at different levels. A continuous rise in temperature was indicated, between the limits of 16° C. at the bottom and 44° C. at the top. In a further experiment a shallow dish was so heated as to give a range of temperature between 16° and 38° C., from one side of the vessel to the other. The general result of these two experiments was to show that the optimum temperature for fixation, in *Plumatella fungosa*, was about 24° C.

(v) *Life-cycle.*—The behaviour of the different species after the end of the sexual period is not identical. It is clear that the statoblasts are not merely hibernating bodies, since many of those formed early in the season can germinate during the summer. Colonies of *Plumatella repens* collected by Marcus (1926[3], p. 293) on July 27 were mostly dead; and, although the majority of their statoblasts had been liberated, a certain number had remained in the dead tubes, where they had germinated. *Cristatella* colonies which had remained active until July 12 began to die about that time, and numerous statoblasts were set free. A few young colonies were hatched on July 29 from some of these statoblasts.

Statoblasts found in autumn, in various species, may have been derived from the following kinds of colonies :— (*a*) from "A" colonies developed from autumn statoblasts which had hibernated and germinated in the spring; (*b*) from "B" colonies formed by the germination of the summer statoblasts of "A"; (*c*) from "C" colonies produced by the larvæ of "A."

The complications of the life-cycle are not fully covered by this enumeration. Colonies of *Plumatella fungosa* found

at the end of May or the beginning of June were mostly disintegrated, partly eaten by predatory animals. Mature sessile statoblasts were already present and most of them began to germinate on July 26 (*ibid.* p. 294); although statoblasts of this kind, occurring in *Plumatella* and *Fredericella*, usually remain in the colonies which are dying at the approach of winter and are destined to germinate in the ensuing spring (Marcus, 1925, p. 18). The colonies of *Plumatella* may be of two kinds:—(*a*) those which are obviously branched, the tubes not being in lateral contact; (*b*) those in which the tubes are closely associated, so as to form a turf-like aggregate. The extreme form of the second type is found in *P. fungosa*, which may grow in masses several inches in diameter, composed of closely packed tubes arranged vertically to the free surface, with their lateral walls in close contact. Marcus states (*ibid.* p. 18) that the first kind of colony originates by the germination of a single floating statoblast, and that the second kind results from the germination of numerous crowded sessile statoblasts. He quotes a well-known observation of Wesenberg-Lund (1896, p. viii), who found evidence, in *P. fungosa*, of the germination of a considerable proportion of 247 sessile statoblasts, on a branch 20 cm. long, which by their united efforts had produced a large compound colony. As an accumulation of large numbers of sessile statoblasts could not persist on the leaves of water-plants which die at the close of the season, the typical *P. fungosa*, with closely-packed parallel tubes, is never found on leaves, but occurs on submerged roots or other substances of a more durable nature.

The duration of life is short in most of the freshwater species. A few cases are known in which colonies have survived a mild winter, but these seem to be exceptional, and in most cases (in our latitudes) active life is restricted to the warmer months. Wesenberg-Lund (*loc. cit.* and pl. ii, fig. 14) described appearances in *P. fungosa* which he interpreted as annual rings of growth; but this conclusion was disputed by Braem (see Marcus, 1925, p. 31), who suggested that the rings in question might have resulted from periods of flood, depositing layers of sediment on the surface of the colony.

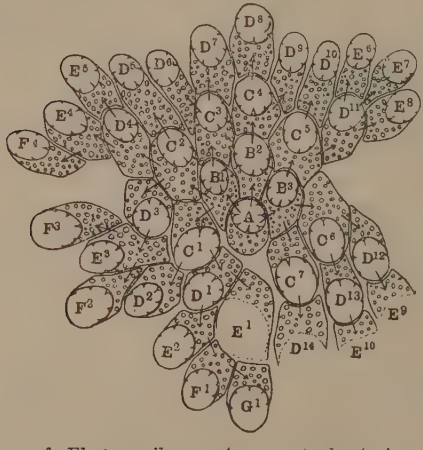
The observations above described refer to the behaviour of freshwater Polyzoa in temperate climates. There are few descriptions of the biology of these animals in warmer latitudes, but it is known that statoblasts occur in tropical species. Annandale observed that, in tropical India, statoblasts, as well as the hibernacula of freshwater Gymnolæmata, are produced specially at the commencement of the hot season (Marcus, 1925, p. 23). Marcus states that, in tropical localities, germination generally occurs at the beginning of the rainy season (*ibid.* p. 17).

B. *Gymnolæmata, Phylactolæmata, and Entoprocta.*

(i) *Normal Growth of an encrusting Cheilostome.*—This process may be illustrated by the account given by Marcus (1926[2], p. 31) of *Electra pilosa*. The commencement of growth in an actual colony is shown in text-fig. 1, and a diagrammatic representation of the succession of the zoœcia of the earlier generations, modified from a part of another figure of Marcus, in text-fig. 2.

A (text-fig. 2) is the ancestrula, which was produced by the metamorphosis of the free-swimming larva, immediately after its fixation. It has given rise to three distal buds

TEXT-FIG. 1.



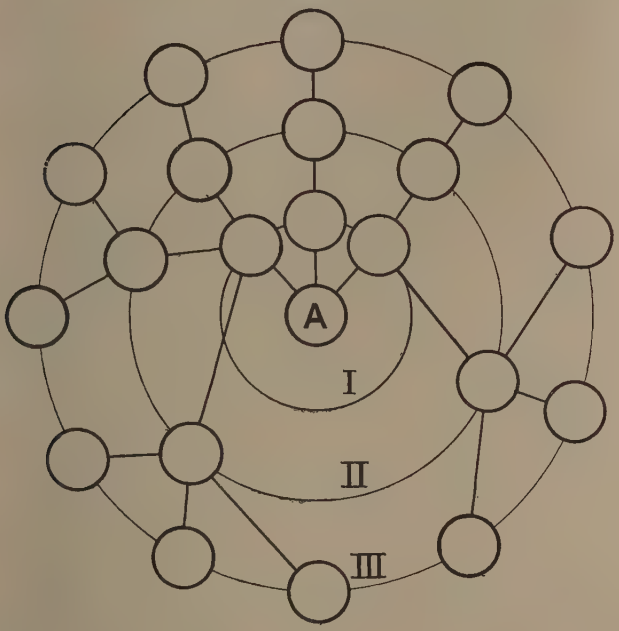
Young colony of *Electra pilosa*. *A*, ancestrula (primary zoœcium, formed by the metamorphosis of the larva); *B–G*, successive generations of zoœcia, produced as buds. The arrows indicate the derivation of the zoœcia from their predecessors. (From Marcus, 1926[2], p. 31.)

(zoœcia), which constitute the first generation (I). When these had become mature they produced a second generation (II), which in this particular colony consisted of six zoœcia. The third generation (III) is composed of eleven zoœcia ; and the colony, probably at this stage rather more than a month old, now consists of twenty-one zoœcia (A + 3 + 6 + 11).

The young colony is typically fan-shaped, but the distal lateral edges of the fan are early reflected and commonly meet one another on the proximal side of the ancestrula, which may thus, in the early life of the colony, become centrally situated in a circular group of zoœcia. The position

of the zoœcia shown in text-fig. 2 does not correspond with their location in an actual colony, in which the reflection of the edges is commonly so great that the inner walls of zoœcia belonging to several of the earlier generations come into contact with the ancestrula. In text-fig. 1 (not diagrammatic) the ancestrula is surrounded by seven zoœcia, of which three belong to generation I, two to II, and one

Text-fig. 2.



Diagrammatic representation of the succession of the first three generations of zoœcia (I–III) in another colony of *Electra pilosa*. *A*, ancestrula. Each generation is represented by one of the concentric circles. (Modified from Marcus, 1926[2], p. 32.)

each to III and IV. It is only the three zoœcia of generation I which were budded off directly by the ancestrula.

As indicated in text-fig. 2, the ancestrula or any zoœcium of the earlier generations may produce as many as three distal successors. In the more complete figure of Marcus from which it has been constructed, the median bud of the ancestrula has originated a uniserial row of ten zoœcia—all the members of this row having produced one distal successor each. The

right lateral bud of the ancestrula has produced two successors ; and the left lateral bud has resembled the ancestrula in giving rise to three buds. The members of generation II have produced one, two, or three successors each ; and in general it may be stated that, throughout the growth of the colony, only one bud is produced where the zoœcia are crowded ; while if more room is available either two or three buds may be developed by a zoœcium. According to Marcus, the production of three buds occurs only in the earlier generations. The tendency afterwards is to form uniserial rows, a zoœcium here and there producing two buds, if space is available, with the result that a new radiating row is intercalated in the colony.

When the colony has completely assumed a circular form, each new generation gives rise to a marginal zone of new zoœcia. The circumference increases at each such operation, and every zone has a larger number of zoœcia than its immediate predecessor. As several generations of buds are produced in a month, it is clear that the monthly production of zoœcia increases at a great rate during the later part of the season favourable for growth. The number of zoœcia which may ultimately be present is sometimes enormous. In the second edition of his ' British Zoophytes ' (1847, p. 348) Johnston mentions a specimen of *Membranipora membranacea* (a species encrusting the fronds of *Laminaria*) which had been observed by Landsborough. It was 5 feet in length and 8 inches in breadth, and the calculated number of zoœcia was above 2,000,000, " about equal in number to the population of Scotland." Loppens (1905, p. xxii) has recorded a colony of the erect bilaminar *Flustra foliacea*, which weighed 13 grms. and was estimated to consist of 1,333,000 zoœcia.

(ii) *Rate of Growth, Duration of Life, and Life-cycle.*—The number of observations on these subjects, in marine Polyzoa, is remarkably small. On plates which had been submerged for two and a half months Loppens (*ibid.* p. xxiii) found circular colonies of *Membranipora membranacea* having a diameter of 6–7 cm. and consisting of about 7000 zoœcia. In *Bugula flabellata*, on submerged bricks, two zoœcia were present on the fifth day after the fixation of the larva ; and on the seventeenth day the colonies, with several branches, had a height of 7 mm. and were composed of about 100 zoœcia.

Orton (1914, p. 316) has recorded the following facts, from observations made at Plymouth. *Bugula flabellata* grew to " a good-sized colony " and gave off larvæ in eight weeks. 100 zoœcia were counted in a colony not more than a fortnight old. " From the observations made there is no doubt that this species passes through several generations during the summer and autumn, and indications were given

that the most rapid growth occurs during August and September." Another species of *Bugula* reached a height of 4 cm. in fifteen weeks. *Bowerbankia* grew to 45 mm. high in the same period, and in nine months the colonies were very large and produced a great number of larvæ. *Bugula neritina* grows into "huge colonies" in the Great Western Docks in a year. Of encrusting species *Lepralia* † *pallasiana* produced circular colonies with a diameter of 11 mm. in eight weeks, and reached a diameter of 31 mm. in twenty-three weeks. *Membranipora membranacea* formed circular colonies 60 mm. in diameter in twelve weeks, an observation which agrees well with the result of Loppens quoted above.

Parker (1924, p. 128) found that in fifty-three days colonies of *Bugula* reached a height of 23 mm., and the encrusting *Electra pilosa* a diameter of 24 mm.

The above records do not decide the months during which the growth took place, and this is clearly a matter of importance. Friedl (1925), as the result of a more detailed study made at Rovigno in the Adriatic, came to the conclusion that there are generally two periods during which free larvæ are produced—the first in the late spring or early summer (May–July) and the second in the autumn (September–October). I quote his results partly from the original memoir and partly from 'Tabulæ Biologicæ' (Marcus, 1930), in which may be found a very useful summary of observations relating to size, rate of growth, and many other facts in connection with the ecology of the Polyzoa.

Table 1 (p. 126) is from Friedl's original, simplified by omitting the half-monthly figures. It represents the monthly growth, in the Adriatic, of an encrusting Cheilostome colony founded at the end of each of the months May–October. The principle on which it was constructed, as explained by Friedl on pp. 155–6, was to calculate the theoretical number of zoœcia, in colonies of *Schizoporella sanguinea* varying in diameter from 1 to 10 cm.—the calculation being based on an estimate of the average area of a single zoœcium. On p. 158 (footnote) Friedl remarks that "Die mit * versehenen Kolonien wurden nicht beobachtet"; and in the original table all the entries under August, September, and October are thus marked. The figures given must therefore be regarded as largely hypothetical, although they appear to correspond fairly with the observed facts, which were obtained by the examination of planks immersed in the sea during known periods.

† I here employ the generic names which were in current use until a few years ago. The new genera which have latterly been introduced in profusion are still in a state of flux, and this is not the place for a detailed criticism of them.

The reproduction by Marcus (1930, p. 314) of Friedl's table is quite accurate, except that the asterisks of the original are omitted—a not unimportant detail.

The colonies whose history is thus summarised were founded by larvæ which did not begin to appear before the end of May. If they attach themselves at this time, growth continues throughout the summer. It becomes less rapid in October, partly as the result of the strain on the reserves of the colonies due to the commencement of sexual reproduction in September, and it ceases in the winter.

A colony which starts at the end of May has four specially favourable months (to the end of September) in which the number of zoœcia increases with great rapidity, particularly after the first two months. It grows less quickly during the

TABLE 1.

	Colony founded at end of	Number of zoœcia at end of					
		June.	July.	Aug.	Sept.	Oct.	Nov.
Summer generation.	May	20	500	*10,000	*25,000	*30,000	*30,000
	June		20	*500	*10,000	*12,000	12,000
	July			*20	*500	*5,000	5,000
Autumn generation.	Aug.				*20	*500	2,000
	Sept.					*20	100
	Oct.						5

Adriatic. Growth of an encrusting Cheilostome, as estimated by Friedl, 1925. The colonies marked with an asterisk were not observed.

fifth month (October), partly for the reason stated above, and then remains more or less at a standstill until the next spring, if it succeeds in surviving the winter.

A colony initiated by a larva which fixed at the end of July has only two favourable months, in which the number of zoœcia increases at a slow rate, because at each new generation the number producing buds is necessarily small. In the third month (October) growth proceeds more slowly, and even at the end of the fourth month these colonies are only half the size of those which have grown for three months, having been founded at the end of June.

A colony which begins its life at the end of either August or September makes little growth before the end of the year.

Friedl came to the conclusion that the duration of life of a colony of *S. sanguinea* does not as a rule exceed six months. In large colonies, most of the zoœcia contain merely brown bodies and they can make no contribution to the total amount of nutritive material present. Although the remains of such colonies may later regenerate to some extent, they do not seem to take much share in the continuation of the species in the spring. Those which are important in this connection are the autumn-founded colonies with relatively few zoœcia, which are sufficiently numerous, however, to give them a marked advantage in the spring. Having successfully hibernated, they commence to grow rapidly in April and they soon develop sexual organs, of the presence of which evidence is given by the appearance of ovicells in the colony. From May to July they produce the larvæ from which the colonies of the summer-generations originate. These, in their turn, produce a second brood of larvæ, from which other colonies are founded in September and October.

Marcus (1926[4], p. 67) points out, no doubt with reason, that Friedl's results cannot be supposed to be of general application, and that the life-cycles of Adriatic species are not likely to agree in all details with those of the same or different species living in other seasonal conditions. He mentions the conflicting statements with regard to the monthly occurrences of *Cyphonautes* as a difficulty in accepting a general scheme of the yearly cycle in marine Polyzoa. This particular objection is not convincing, because various different forms of this larva are known and these are probably specific. Few of the records can claim to have established the specific identity of the colonies which can develop from the larvæ observed; and if the facts were known it might prove that the species which produce this type of larva have different breeding-seasons, even in the same locality. Marcus thinks that many of the North Sea species of Polyzoa probably live for several years, growth stopping in the winter, but re-commencing in the spring.

In the course of his investigations on growth, Friedl made observations of great interest, as elucidating to some extent the nature of a variation known to occur in *Scrupocellaria*. In certain species of this genus each zoœcium is protected, on its frontal side, by a modified spine, the scutum, which overarches the front from one side, where it is attached. The scutum, which is usually a circular or oval shield, is often variable in its occurrence, being sometimes absent in certain colonies of species which normally possess it, or absent in some zoœcia and present in others. Friedl found that, in *S. reptans*, in which the scutum is branched, the colonies of the summer-generation have it well branched (*forma typica*). In the

autumn-generation it becomes less and less branched, in correlation with the date on which the colony was founded by the fixation of the larva. The later this event happens, the less branched are the scuta of the colony. Those in which the scutum is only moderately branched have been described as a distinct species, *S. bertholletii* (Aud.). In late autumn the young colonies develop only weak, simply forked scuta, and this form is *S. capreolus* Heller. In colonies produced towards the end of autumn or the beginning of winter the scuta are absent or very slightly developed, only a few zoœcia possessing a very small forked scutum—and these may be mistaken for *S. scruposa* (Linn.). In this series of forms, as in other species of the same genus, several different conditions of the scutum may be found on the same colony. If these results are correct, they suggest that more attention should sometimes be paid to the dates on which specimens have been collected than is usually given to this detail in taxonomic work.

An estimate of the rate of growth, based on a different line of evidence, has been made by Rey (1927), who states that in *Flustrella hispida* the active life of a polypide is nearly constantly three to four weeks. The new polypide is visible in the zoœcium twenty-four hours after the commencement of the degeneration of the preceding polypide. Growth takes about a week, and the tentacles can be protruded at the end of eight or nine days. The length of life of a polypide, from the stage when it is first visible as a commencing bud, is thus from four to five weeks. This is a species in which the brown body formed by the degeneration of a polypide is not evacuated, but remains in the zoœcium. In a colony examined at the middle of August, the oldest zoœcia had four brown bodies and a young bud. The colony was accordingly estimated to be about four months old, and was probably founded in the spring.

The observations made by Grave (1930), at Woods Hole, Massachusetts, give a very complete account of the behaviour of *Bugula flabellata* at that locality; though, from various facts he mentions, it does not seem to be certain that his species is identical with the real *B. flabellata* of European seas. This species and *B. turrita* occur in two closely adjoining localities: *B. flabellata* in Eel Pond, in which the water is comparatively still, and *B. turrita* in Vineyard Sound, where the tidal currents are strong. Each species is restricted to its own particular habitat, and when either is transported to the other locality it fails to thrive, and after a few months or a year it disappears. The facts indicate a physiological difference between two closely allied species; but, as in other cases of the same kind, the nature of the difference is unknown.

The colonies of *B. flabellata* were found to become senescent usually at the age of three months, when they had reached a height of about an inch and a diameter of $1\frac{1}{2}$ to $1\frac{3}{4}$ inches. Those which are founded at midsummer are rather larger than the earlier and the later ones. After November there are no active polypides and each zoœcium contains a single brown body. It is not explained how this result is attained. The brown body in species of *Bugula* is believed not to be extruded through the alimentary canal of the replacing polypide. It might have been anticipated that each of the old zoœcia would have contained several brown bodies, recording the degeneration of a corresponding number of polypides.

The ancestrula resembles the other zoœcia (which is by no means universal in Polyzoa), and its tentacles can be protruded at the age of 2 days. It invariably has five spines, the number of which in the European *B. flabellata* has been observed to be seven to nine. The second zoœcium is complete on the fourth day, two days being the normal length of time taken by an individual to attain its full development, from its first appearance as a bud. As the number of individuals which can produce distal successors is constantly being increased by the repeated bifurcations of the branches, many buds develop simultaneously after the early stages of the life of the colony. Eight zoœcia are present at the end of the first week, and in ten days there are twenty or more zoœcia; in a fortnight, 100–170; and in a month the colony is half grown and has become sexually mature. Avicularia had begun to appear when the colony consisted of about ten zoœcia.

The breeding-season commences during the first or second week in June, its extreme limits being from about June 1 to November 20. Metamorphosis of the larva can be successfully accomplished as late as November 20, but the colonies thus founded consist of no more than one to eight zoœcia. They pass the winter in this condition, and, like other colonies which have successfully hibernated, they do not resume growth until after May 1. The very last larvæ which succeed in their metamorphosis are usually attached to older colonies, and they pass the winter as single zoœcia. These and others consisting of as many as eight to sixteen zoœcia are the first to commence growth in the spring. Grave thinks that some of the larvæ metamorphose in the ovicells and hibernate there, but the evidence he gives for this statement is not conclusive. The largest colonies do not usually survive the winter, but young colonies are more successful in this respect, and those founded after September 25 are the most resistant to cold. When an older colony lives through the winter

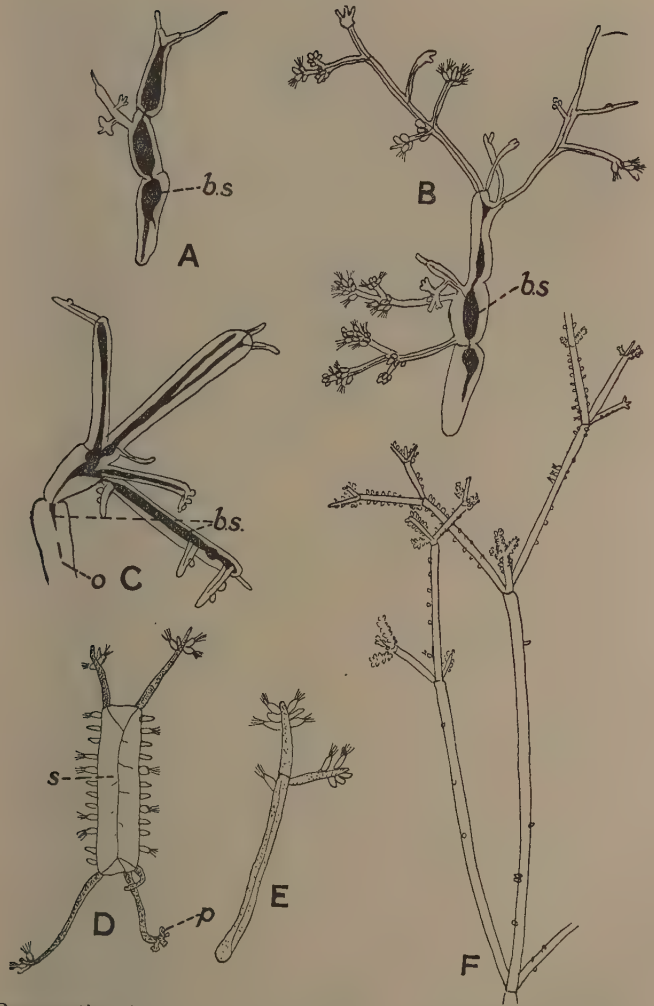
it begins to regenerate in the spring, and a single surviving zoœcium may start a new colony. If the two or three proximal individuals survive they may give rise to stolons which produce buds that develop into new colonies. It may be remarked that this method of growth has often been described in other branching marine Polyzoa.

As happens in many other animals, the larvæ are hatched at a particular period in the twenty-four hours. They begin to hatch at dawn, and are liberated in increasing numbers until 9–10 A.M., after which fewer are produced. None are liberated at night, and but few in the afternoon. Colonies kept in the dark produce no larvæ, which appear when light is admitted. The larva is strongly attracted by light for two or three hours, and 100 per cent. were found to react thus. The response to light becomes reversed after this time, the negative phototaxis when established being as universal as the earlier reaction. During the later period the larvæ could be driven in any desired direction by appropriate shading. The negative reaction results in the fixation of the larvæ in shady places, where the colonies of this species are actually found growing in Nature. Fixation does not take place quickly in a very dim light, and may be prevented altogether by keeping the larvæ in complete darkness. Larvæ hatched at 7–8 A.M. began to attach themselves at 11–12 o'clock, and were nearly all fixed by 2 P.M.

The response to gravity is negative, as shown by the fact that fixation takes place close to the surface of the water when the larvæ are kept in complete darkness. Marcus (1926[1], 1926[3]) has come to similar conclusions, also based on experimental evidence, with regard to the larvæ of Phylactolæmata. The negative responses to light and gravity are in opposite directions in Nature, and the actual direction of movement of the larvæ appears to depend on which is the stronger at any given time. Grave seems to have found convincing evidence that, in *Bugula*, the reaction to light is reversed with some suddenness at a particular phase of the free life of the larva.

Zirpolo, in a series of papers published 1922–1925, has recorded a number of interesting facts, observed at Naples, with regard to the life-cycle and regenerative processes of *Zoobotryon verticillatum* (Delle Chiaje) = *Z. pellucidus* Ehrenberg (text-fig. 3, F). This remarkable member of the Ctenostomata is extremely abundant at Naples, where it is found on the timbers of the bathing establishment and on other submerged objects near the surface of the water. It forms large and profusely branched colonies, which according to Reichert (1870, p. 235) may reach a height of 18 inches, with a circumference of 3–4 feet (at Trieste), and its delicate

TEXT-FIG. 3.



Regeneration in *Zoobotryon verticillatum*. A, regenerative branch, Sept. 10; B, the same branch, Oct. 5; C, another regenerative branch, with its origin from an old branch, autumn; D, regeneration of a portion, Aug. 7, cut from an old branch on Aug. 4; E, one of the regenerated branches of D, on Sept. 5; F, portion of an adult colony. *b.s*, blastogenic substance; *o*, fragment of old branch; *p*, process for fixation; *s*, section of old branch. (A, B, from Zirpolo, 1923[1]; C, from Zirpolo, 1923[2]; D, E, from Zirpolo, 1924[2]; F, from Reichert, 1870.)

and translucent character makes it an object of much beauty. It develops with great rapidity during the spring and summer, until September or October, when the colonies lose their turgidity and break up, branches being carried about in the water, thus helping to distribute the species. In certain parts of the colonies small branches with no zoœcia and in other respects differing from the normal ones appear at this time (1923[1]). They contain a large quantity of yellow nutritive material, the "sostanza blastogena," at the expense of which further development can take place. A branch of this kind (text-fig. 3, A) which was observed in September consisted of three short segments nearly filled with the blastogenic substance (*b.s.*), and the middle one was giving rise to a lateral branch. It was kept under observation until the following February 27. Until October 5 (text-fig. 3, B) it continued to develop branches, which produced zoœcia, a process associated with the reduction of the blastogenic substance; but after this date its growth was retrogressive and at the end of February it appeared to be almost dead. The observations had been made in aquarium conditions, and the course of events had probably not been completely normal. Other observations (1923[2]), also made in the autumn, showed that the regenerative branches are highly variable in their form and arrangement, and they indicated clearly that their blastogenic substance had been transferred to them from the nutritive material in the dying branches of the old colony (text-fig. 3, C). In normal conditions, according to Zirpolo, these regenerative branches are deposited at the bottom of the sea, where they hibernate and recommence growth in the spring. The zoœcia then become sexually mature and produce larvæ, which give rise to the large summer colonies.

In another paper (1924[1]) Zirpolo describes the results obtained by observing the behaviour of residual portions of summer colonies found, towards the end of October, in the neighbourhood of ships (apparently floating freely in the water). In portions isolated for this purpose, all the branches fell off, leaving merely an axis, without zoœcia but containing a considerable amount of blastogenic substance, which had presumably accumulated there during the disintegration of the rest of the colony. The axis persisted during the winter, but no signs of regeneration were detected until early in April. A fragment, 15 mm. long, formed of two segments nearly filled with blastogenic substance and already possessing small lateral outgrowths, was selected for detailed observation on April 4. On April 12 the lateral branches had grown considerably and had produced zoœcia, and on April 13 they had further increased in size, the blastogenic substance being perceptibly reduced in amount. The observations were continued for some weeks, and during this period the develop-

ment of the branches first reached a maximum, and the two segments of the axis, with their branches, then underwent retrogressive changes. This seems to have been due to the artificial conditions of the experiment, though Zirpolo does not say so, and his conclusion is that some at least of the branches thus formed in the spring would normally become free and give rise to new colonies capable of producing larvæ.

Later researches (1924[2]) by the same author showed that *Zoobotryon* possesses extraordinary powers of regeneration after injury, most active in the young branches. Experiments made by cutting the stems into various known lengths showed that their subsequent behaviour depended on their position in the original colony. Branches of the first order (main branches of the colony) regenerated a single stem at one end. Those of the second order behaved in the same way, but with greater activity. Those of the third to fifth orders regenerated at both ends, the fourth more actively than the third, and the fifth with an extraordinary activity surpassing that of all the other orders. At least four regenerated stems were commonly developed by the sections of these younger branches (text-fig. 3, D). These produce zoœcia, break away separately (E), and attach themselves by a digitate process (shown in text-fig. 3, D, *p*), at their proximal end, to a solid object. It appears probable that a similar method of regeneration occurs in Nature in branches which have broken away from the old colonies.

(iii) *Budding under experimental Conditions.*—The interest of the observations of Marcus (1926[2]) is increased by the fact that some of them throw light on certain supposed abnormalities, or variations, which are to be found in Nature. The normal growth of an encrusting colony presupposes a suitable substratum on which it can continue to extend. Experiments with *Electra pilosa* showed that, in the absence of this "contact-stimulus," the zoœcia ordinarily formed at the growing margin are replaced by long tubular structures, which Marcus terms "Haftzoœcien" (attachment-zoœcia). A colony removed from its substratum and suspended horizontally in the water produced zoœcia of this kind all round its edge. They at first showed a distinct geotropic tendency, since they grew vertically downwards. As there was nothing to which they could attach themselves in that direction, they later curved round, so as to come into contact with the basal surface of the colony. Here they found the appropriate contact-stimulus, after which each segmented into a row of three or four perfectly normal zoœcia.

On removal of the substratum below a part of the growing edge of a normally encrusting colony, attachment-zoœcia with a geotropic growth were at once produced.

In another experiment, a detached colony was arranged

so as to lie partly on another colony of the same species and partly on a *Laminaria* frond, and attachment-zoœcia were soon developed at its growing margin. Those which reached the *Laminaria*, a suitable substratum, segmented into normal attached zoœcia. Those which were lying on the other colony were unable to behave in this way, because the substratum was unsuitable and the contact-stimulus was not of a kind to produce the desired result.

If two colonies on the same substratum meet by their growing edges, they make no attempt to overgrow one another, and Marcus is of opinion that the armament of spines possessed by normal colonies is an arrangement which prevents them from being covered by other colonies of their own or other species. In another paper (1926[4], p. 71) Marcus supports a suggestion I had myself made (1909, pp. 720–722), that many of the generic and specific characters of marine Polyzoa have a similar significance. The delicate flexible membrane which covers many species is unsuitable for the fixation of encrusting animals which require a hard and rigid substratum. Marcus has made the interesting observation that, while a colony of *Electra pilosa* can extend its growth across a narrow interval to a neighbouring object, it makes no attempt to do so if there is the least instability in that object. The irregularity of surface due to the pronounced convexity of the zoœcia in many species not protected by avicularia is unsuitable for the fixation of organisms which require a smooth substratum, and the spines or tubercles so commonly found in calcareous Polyzoa are also effective in making the surface irregular.

(iv) *Functions of Avicularia.*—The avicularia with which so many species of Cheilostomata are abundantly furnished are probably an efficient protection against the encroachments of other encrusting organisms. The danger to be avoided is not necessarily, however, overgrowth by a colony on the same substratum. I have previously mentioned (1909, p. 720) certain facts which seem to make it probable that the avicularia are specially important in preventing the fixation of larvæ which would develop into an encrusting film. I was thus specially interested in reading a statement by Marcus (1926[4], p. 58) that Brücker had actually observed the warding off of the larvæ of *Scrupocellaria* by the avicularia of *Bugula*. I regret that I have to mention this in order to call attention to the fact that it is not quite correct. The original statement (Brücker, 1912 p. 123) is as follows :—the movements of the avicularia of *Bugula* "seemed to me to be rather for the warding off of foes and intruders than for the capture of prey. The fact that the Bugulidæ are always strikingly

clean and free from attached parasites is in favour of this conclusion, while the Scrupocellarias are always covered by them" (translation). The absence of other organisms on the surface of *Bugula* may well be due, as Brücker suggested, to the special efficiency of the bird-like stalked avicularia of this genus; but the statement I have quoted is not quite what Marcus says.

It must not be supposed, however, that the avicularia are used solely for protecting their possessors against larvæ. It has repeatedly been observed that they capture and hold fast intrusive animals, such as small worms and Crustacea. I agree with Brücker and Marcus that this is probably a purely defensive action which has no connection with the capture of food—a function which has been attributed to them. Marcus justly observes (1926[4], p. 58) that the amount of nutrient material the avicularia capture is quite inadequate for the needs of the colony, and that what is caught by them is not the kind of food on which Polyzoa subsist. He has pointed out elsewhere (1925, p. 13) that Polyzoa are extremely voracious and that as they do not digest their food at all completely they have an enormous appetite. He states (p. 11), referring to the Phylactolæmata, that the food consists of Oscillatoriæ, Diatoms, Desmids, Protozoa (Flagellata, Ciliata, and *Arcella*), the smallest Rotifers, etc. The marine Polyzoa use similar food, consisting of Diatoms and other small constituents of the plankton. Hentschel (1922, pp. 12–14) found that the *Membranipora* encrusting *Sargassum* in the Sargasso Sea had been feeding not only on Diatoms, Coccolithophoridæ and Peridinians, but on a very remarkable food, the nematocysts of a Cœlenterate, probably *Physalia*, the Portuguese Man-of-War. At one Station nearly all the alimentary canals were filled with these nematocysts, which were also found in other animals, such as *Lepas* and *Spirorbis*, in the same localities. If I understand the account correctly, it appears that the tentacles of the *Physalia* are supposed to become broken up by the waves, so that the nematocysts occur floating freely in the water. The diet seems to be a singular one, but there are reasons for believing that the Polyzoa select their food and do not merely swallow anything which happens to be driven to their mouths by ciliary currents. It may be surmised that the animals which devour nematocysts enjoy a highly seasoned food, since the poisonous fluid of the nematocysts probably has this character.

There seems to be no evidence that the occasional capture of small animals by avicularia is in any way connected with feeding. The response of avicularia to mechanical stimuli (see p. 138) is of a kind which agrees well with the view that these structures are defensive.

Buchner (1924) has obtained very interesting results with regard to another function which may be assumed by avicularia, although this may be considered a subsidiary or additional function, which in no way modifies the conclusion that these structures are in the main defensive. The colonies of Reteporidæ are highly calcified and rigid, forming expansions of various forms which arise from a narrow base of attachment. The zoœcia are almost invariably confined to one surface of the expansions, which are usually beautifully reticulate. Additional strength is given to the branches and to the basal plate by numerous calcareous structures which had been regarded as kenozoœcia, a name applied to modified zoœcia which have no polypide and no orifice for the protrusion of tentacles. Buchner has produced satisfactory evidence that the supposed kenozoœcia are for the most part avicularia. These are found on both surfaces of the branches, but those on the basal surface must have a relatively short life, since they become completely covered, in due course, by other avicularia which are developed outside them. As this process is frequently repeated, a transverse section of an old branch shows zoœcia on the frontal side, the rest of the branch being composed of successive layers of buried avicularia, in which the mandibles can often be detected. The basal plate of the colony is similarly constituted of tiers of modified avicularia, which are, in fact, used as the building-stones of an edifice. It would be interesting to ascertain whether avicularia are used in the same way by other massive calcareous Cheilostomes, in many of which secondary strengthening of the colony is known to occur.

(v) *Correlation in the Activities of the Colony.*—In certain groups of animals such as the Siphonophora, there must be a definite correlation of the activities of individual zooids, as in the case of the nectocalyces, by which movement of the colony is effected. With respect to movements, the Polyzoa show singularly little co-ordination of the individuals, each of which acts to a large extent without reference to what its neighbours are doing. There is ample reason to believe, however, that the nutritive material present at any one time is a common stock, which is at the disposal of any individual that needs it (see pp. 132, 133). Although each zoœcium is completely separated from its neighbours, in the marine Polyzoa, by complete chitinous or calcareous partitions, these walls are provided with pores, the septulæ or rosette-plates, which are traversed by strands of living tissue connecting adjacent zoœcia. It may safely be assumed that this is the way in which nutritive material can pass from one individual to another.

The capture and assimilation of food is performed exclusively by the polypides, but there are many individuals in a colony in which these do not occur. The avicularia (with rare exceptions), vibracula, and kenozoœcia are at no time provided with polypides, and, throughout their lives, they are dependent on the individuals which actually feed. On the degeneration of a polypide, its zoœcium can draw on the resources of the colony for material which may be required for the formation of a new polypide. The same behaviour is even more obvious in the budding zone, where the zoœcia, which are formed first (in the Gymnolæmata), have to develop a complete polypide before they can obtain their own food. Marcus (1926[2], p. 34) has observed that the time required for the development of a new zoœcium at the budding margin diminishes with the growth of the colony; and he attributes this to the fact that, with increasing numbers of feeding individuals, the total store of nutriment becomes more ample. The large number of embryos found in a Cyclostome ovicell, which has no polypide except in the initial stage of its growth, must be nourished at the common expense of the colony.

With regard to movements, the correlation of the activities of the vibracula of *Caberea*, as originally observed by Hincks, stands almost by itself. The general rule is that each individual acts without reference to what its neighbours are doing. Thus Marcus (1926[2], p. 54) is able to make the generalization, based on his own careful experiments, that no individual, whether of the Gymnolæmata or of the Phylactolæmata, reacts to a stimulus applied to a neighbour. If the exserted tentacles be touched by a needle, they will probably be at once withdrawn, but the nearest polypides will not be affected. In *Farrella repens*, in which each zoœcium comes off separately from a creeping stolon, the whole of the outside of the zoœcium is more sensitive to mechanical stimuli than are the tentacles, and Marcus (pl. i) has ascertained the presence of a well-developed nervous plexus in its body-wall. The plexus does not extend to the stolon from which the zoœcia are budded, and stimulation of the stolon thus produces no result, while irritation of a zoœcium does not affect its nearest neighbour. In the Phylactolæmata the zoœcia have to a large extent lost their individuality, their body-cavities being continuous. In *Cristatella* it is no longer possible to recognize individual zoœcia, and in this genus the body-wall is more sensitive than the tentacles (Marcus, 1926[3], p. 329). If the outer wall is stimulated with sufficient intensity, several of the expanded polypides will be withdrawn, and an injury to one polypide may affect others—an exception to the generalization above quoted. Marcus infers the existence of a colonial nervous system in the body-

wall, in *Cristatella*, but he has not observed it. The larvæ of Phylactolæmata have a nervous network, with associated sense-cells, in their body-wall (Marcus, *ibid.* pl. vi), most developed at the pole by which fixation is accomplished. It may be assumed that, as in other orders, this enables them to respond to the contact-stimulus of an approprate surface for fixation. For additional information on the nervous system of Polyzoa reference may be made to Graupner (1930).

(vi) *Other Effects of Stimuli.*

(a) *Mechanical Stimulation.*—Mechanical stimulation of the avicularia of *Bugula* produced no response in the zoœcia, and *vice versa* (Marcus, 1926[2], p. 56). The avicularium with open mandible shows no reaction to a stimulus applied to its outer wall or to its mandible ; but it closes at once when its palate is touched. This confirms the belief that a well-known organ on the palate is of sensory nature.

With regard to the vibracula, the seta is insensitive. In the resting position the setæ of *Scrupocellaria* lie on the basal surface of the branch. When the frontal surface of a zoœcium is stimulated, the two setæ in its neighbourhood beat over it. It can hardly be doubted that if the stimulation were given by the contact of a larva with the branch the movements of the setæ would disturb it and probably prevent it from fixing. No co-ordination of the movements of the setæ has been observed in this genus.

(b) *Alterations of Temperature.*—The reaction of the polypides to a stimulus of this kind is commonly indicated by their retraction, often followed by an evagination during which the tentacles assume what Marcus terms the " Ekelstellung "—a word which may be translated as " attitude of disgust " or " of aversion " (see 1926[2], fig. 29*b*, p. 54). The polypides then retract once more, after this exploration by the tentacles, and remain retracted.

Electra pilosa, which had become habituated to an aquarium temperature of about 20° C., reacted in this way, on the average, at 26°·1 C. With *Farrella repens*, at an initial temperature of 21° C., the water could be raised to about 30°·2 C. before this reaction was observed. There was, in this species, a preliminary period of excitability at 24°–26°, shown by repeated retractions and evaginations, and at 27°–28° many eggs were laid, but more rapidly than is usual. A few polypides remained protruded at 32° or more, but they were obviously injured by the high temperature, as they no longer responded to a mechanical stimulus, even if this took the form of cutting off the tentacles.

In experiments in which the water was cooled, *Electra pilosa* with an initial temperature of 19°·5 C. reacted at 11°·7

(average), and *Farrella repens*, at first at 20°·5 C., at 12°·8 (average). Although there is not much difference between the species, as shown by these figures, Marcus points out that *F. repens* is really less tolerant of cold than is *E. pilosa*. At 17° the tentacles of *E. pilosa* remain normally expanded and they respond quickly to mechanical stimuli, while at the same temperature fewer polypides of *F. repens* remain expanded, and their irritability is reduced. At 7° C. *E. pilosa* still responds to mechanical stimuli, but *F. repens* no longer reacts at this temperature, and is already "stiff with cold." These facts agree with the distribution of the two species, since *E. pilosa* is found as far north as S. Labrador and Greenland, while *F. repens* does not extend north much beyond the German coast. Marcus obtained evidence that the thermal stimulus affected the tentacles and not the walls of the zoœcia.

Similar results were obtained with freshwater Polyzoa (Marcus, 1926[3], p. 339). In cooling experiments *Paludicella* reacted at the lowest temperature, 8°·7 C. (average), and this species is known to be capable of remaining active during a mild winter. *Plumatella repens*, sometimes found in cold water, came next, with a reaction at 10°, and *Fredericella*, also capable of living in cold water, responded at 12°. Old colonies of *Plumatella fungosa*, which had been growing since April, reacted at 15°, but larval colonies with one to three polypides which had been produced in June were less tolerant of cold, and showed inconvenience at 18°. *Cristatella*, which is usually found in warmer water, responded when the temperature was reduced to 17°.

(c) *Alterations of Salinity*.—The experiments of Marcus (1926[2], p. 66) on the effects of altered salinity were made at Büsum, on the North Sea coast of Holstein. The average salinity at this locality is 35 per thousand. The method adopted was the same, *mutatis mutandis*, as in the temperature experiments. The salinity was increased or reduced by gradual stages, and the Polyzoa were left for a time in each new concentration, in order to accustom them to the altered conditions, before transferring them to a solution departing further from the normal.

In experiments with *Farrella repens*, a reaction was indicated by a reduced sensibility to mechanical stimulation of the tentacles. The first definite reaction, on reducing the salinity, was observed at a concentration of 28 ; and at 21 the tentacles showed no response to mechanical stimuli. The animals were capable, however, of adapting themselves to this concentration, since they became normally irritable after being left in it for one hour. If the change was too abrupt, as by transferring them from normal water to a salinity of 26,

the polypides were inconvenienced, as shown by the attitude of aversion ("Ekelstellung") assumed by the tentacles; but even in this case they became normal after twenty-four hours in the solution. Other experiments showed that the colonies could recover in normal sea-water even after exposure to a salinity of 14·6, although a smaller reduction might produce degeneration of the polypides.

The range of salinity within which the two species investigated can adapt themselves to altered conditions seems to be from concentrations of about 53 to about 17·5 for *E. pilosa*, and from 59 to 14 for *F. repens*. A littoral species, and particularly one which may occur in estuarine conditions, is exposed in Nature to considerable variations of salinity. *F. repens* seems to be the more tolerant of estuarine conditions, and the experiments show that it can withstand a slightly greater reduction of the concentration than the other species.

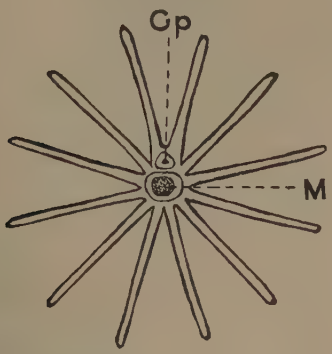
(vii) *Excretory Canal of Phylactolæmata and Intertentacular Organ.*—The two structures here considered are of very restricted occurrence in Polyzoa, and they cannot therefore be supposed to be the organs of most importance in performing any of the major processes essential to the life of all members of the Phylum. But no mention of them would be complete if it did not indicate that, when they are present, they may take part in the function of excretion.

(a) *Excretory Canal of Phylactolæmata.*—This is a vesicle, situated in the lophophore, near the ganglion, and it is believed to be a part of the cavity of the lophophore. Gerwerzhagen (1913, p. 14) has shown that carmine injected into the body-cavity of *Cristatella* is taken up by the peritoneal cells, which become free and make their way to the excretory canal. The epithelium of this organ also absorbs the carmine, which it later eliminates into its own cavity. The pigment ultimately escapes through a rupture in the body-wall, a permanent opening to the exterior being apparently not present. Gerwerzhagen considered that the organ is an accessory structure without morphological significance.

(b) *Intertentacular Organ.*—This structure, which occupies much the same position as the excretory canal of *Cristatella*, agrees with that organ in being able to take up experimentally introduced coloured substances into its epithelium, but, as it opens directly to the exterior it has no difficulty in getting rid of the pigment. This may happen within forty-eight hours, the epithelium resuming its normal uncoloured appearance (Marcus, 1926[2], p. 7). It is possible that the organ may also evacuate excretory substances which have accumulated in the body-cavity, into which it opens.

The fully developed intertentacular organ is found only in the polypides of zoœcia which are producing eggs, for which it provides a means of escape, and it is known in a very restricted number of species, such as *Electra pilosa*, in which the eggs are of small size and are destined to develop in the outside water into a *Cyphonautes* larva. In certain other species, as in *Farrella repens*, a polypide may possess a pore (text-fig. 4, *Gp*) through which the eggs escape from the body-cavity. This is situated in the same place as the intertentacular organ, with which it seems to be homologous, and it may be described as the genital pore. Marcus (1926[2], p. 76) has observed the process of laying the eggs in *Farrella repens*, and he refers to the accurate account of this event which was given by Van Beneden (1845, p. 18, pl. i, fig. 1, B),

TEXT-FIG. 4.

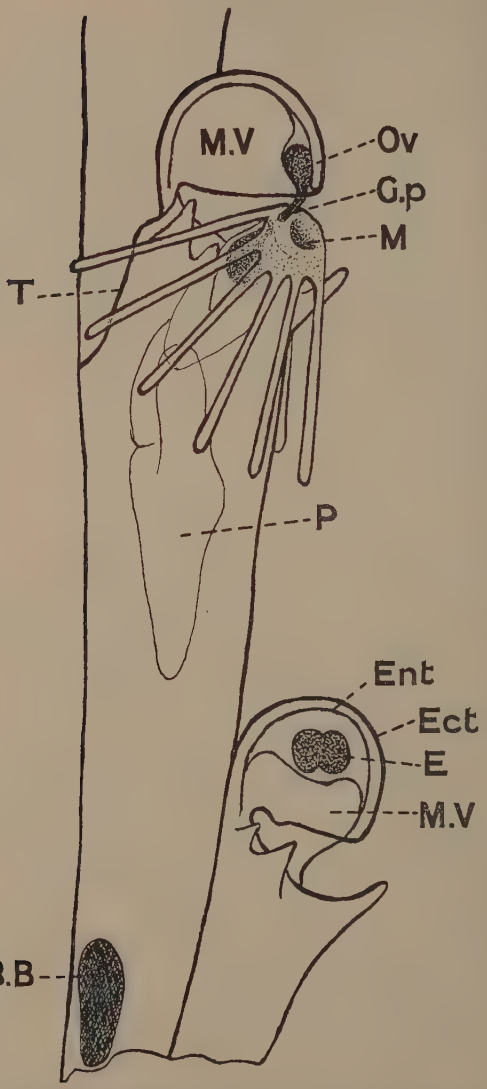


Oral view of tentacles of *Farrella repens*.
Gp, genital pore ; *M*, mouth. (After Marcus, 1926[2], p. 72.)

in the same species. According to Marcus, the behaviour of the polypide in laying its eggs is alike in this species and in *Electra pilosa*, which he also observed successfully.

The entry of the ripe egg into the genital pore or into the intertentacular organ takes place only during the extended position of the polypide. If retraction takes place after the commencement of the process, but before its completion, the egg is laid into the tentacle-sheath, and reaches the exterior at the next evagination. The eggs (in *E. pilosa*) were often swallowed on being laid and were observed to pass through the alimentary canal, escaping by the anus, probably (as Marcus thinks) unharmed. Ripe eggs which occur in a zoœcium with a degenerated polypide (as occasionally happens) disintegrate. According to Marcus (1926[2], p. 74) the genital

TEXT-FIG. 5.

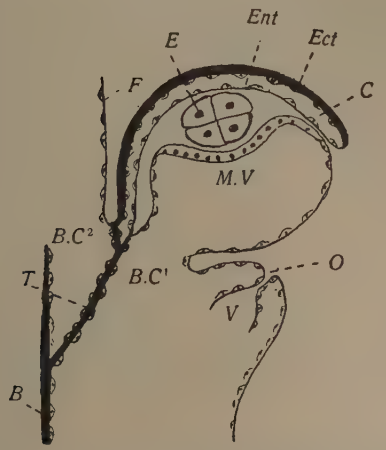


Bugula avicularia, passage of egg into ovicell. *B.B*, brown body: *E*, embryo ; *Ect*, ectocœcium ; *Ent*, entocœcium ; *G.p*, genital pore ; *M*, mouth ; *M.V*, membranous vesicle ; *Ov*, egg ; *P*, alimentary canal of polypide ; *T*, terminal wall of fertile zoœcium. (From Gerwerzhagen, 1913, p. 4.)

pore occurs in all polypides of *Alcyonidium mytili*, whether with gonads or not, but there is some confusion in literature with regard to this species, in which a ciliated canal by which the larva escapes, after having developed in the body-cavity, is not an intertentacular organ.

The genital pore remains uncoloured in solutions containing coloured substances which are capable of being excreted, and in this respect it differs from the intertentacular organ. It is inferred by Marcus that spermatozoa may escape by the pore, as they were observed by him on the tentacles of *Farrella*,

TEXT-FIG. 6.



Bugula sabatieri, diagrammatic longitudinal (sagittal) section of ovicell. *B*, basal wall of zoœcium; *B.C*¹, body-cavity of fertile zoœcium; *B.C*², body-cavity of distal zoœcium; *C*, cavity between ectoœcium and entoœcium; *E*, embryo; *Ect*, ectœcium; *Ent*, entoœcium; *F*, frontal wall of distal zoœcium; *M.V*, membranous vesicle; *O*, orifice of zoœcium; *T*, terminal wall of proximal zoœcium; *V*, vestibule. (After Calvet, from Harmer, 'Siboga' Report, p. 202.)

but it is still uncertain what is the normal method of fertilization in Polyzoa. Ripe eggs and spermatozoa are often found in the same zoœcium, and self-fertilization seems likely to occur, in many species at least. It is possible, on the other hand, that spermatozoa derived from another individual might pass in through the genital pore. Marcus did not succeed in finding spermatozoa of *Electra pilosa* outside the zoœcia and he states that in this species they die in sea-water.

The mode of entry of the egg into the ovicell, in species of Cheilostomata provided with this structure, was completely unknown until it was described by Gerwerzhagen (1913, p. 3), who observed the process in *Bugula avicularia*. The small egg becomes free in the body-cavity and passes to the exterior through a median genital pore (text-fig. 5, *G.p*), as in *Farrella*. At the moment when the egg is laid, the tentacles of the protruded polypide are bent sharply in a proximal direction. The genital pore is thus brought close to the free edge of the ovicell, into which the egg is directly laid. The brood-chamber (text-fig. 6) is morphologically an external space, since the egg develops between the well-known membranous vesicle (*M.V*), which is a diverticulum of the distal body-wall of the fertile zoœcium, and the entoœcium (*Ent*), the inner layer of the wall of the ovicell.

Gerwerzhagen is so circumstantial, and his figure representing the process is so clear, that the accuracy of his account may be assumed. With the case next to be described there are now two instances in which the passage of a small egg into the brood-space has been described—a small proportion of the hundreds of species of Cheilostomes in which ovicells are found. It remains to be ascertained whether the method is general, as it may be; but it is not certain that the large, heavily yolked eggs of most Cheilostomes pass into the ovicells in a similar manner.

A more recent description of egg-laying in Cheilostomata has been given by Paltschikowa-Ostroumova (1925, p. 100), in *Membranipora* (or *Tendra*) *zostericola* and *M. repiachowi*, in both of which the larva is said to be a *Cyphonautes*. In the second half of the summer, which is the sexual period, all the polypides of *M. repiachowi* develop an intertentacular organ, but in *M. zostericola* this structure appears only in those zoœcia which develop ovaries and are situated immediately on the proximal side of one of the "cellules treillissées," which were described by v. Nordmann (1840, iii, p. 670, pl. ii, fig. 2) in his original account of this species, which inhabits the Black Sea. In these zoœcia the frontal membrane is protected by a series of transverse costæ, on either side, as in Cribrilinidæ. The eggs develop in the space between the costal shield and the frontal membrane, as was shown by v. Nordmann, and this kind of brood-space seems to be unknown in any other species. When the laying process is to be accomplished, the tentacles of the fertile polypide are protruded and placed close together, their tips being inserted below the proximal edge of the costal shield of the trellised zoœcium on the distal side of the zoœcium which has produced the eggs. It is in this attitude of the polypide that the eggs pass through the intertentacular organ into the brood-cavity.

(viii) *Excretion, Degeneration, and Regeneration.*

(a) *Gymnolæmata.*—As shown by the experiments of Marcus (1926[2]), who confirms in the main observations previously made by myself (1891), excretion in Polyzoa is generally performed by various parts of the body which are largely concerned with other functions. After four or five hours in a methylene-blue solution of suitable strength, the ectoderm of the tentacles takes up the colour before any of the other tissues do so, and the vacuoles containing the pigment later burst and discharge the foreign substance to the exterior. The species on which Marcus made his experiments were *Farrella repens* and *Electra pilosa*. The epithelium of the intertentacular organ of the latter becomes intensely coloured by the methylene-blue, but, as Marcus points out, this organ is ectodermic in origin and its behaviour towards excretory substances is like that of other parts of the ectoderm. The alimentary canal, the phagocytes of the body-cavity, and the undifferentiated tissue of the budding zone are also concerned with excretion. In *Farrella* the pigment was at first taken up by the walls of young alimentary canals which had not yet developed the normal pigment they would possess later in their lives. This brown pigment, which is very characteristic of the mature polypides, is itself an excretory product. When the cells of the alimentary canal contain it in quantity they have no room for further excretory matter, and accordingly they do not, at this stage, absorb the indigo-carmine. The pigment, whether normal or experimentally introduced, is not readily discharged by the cells of the stomach, so that the normal degenerated polypide has the colour indicated by the term "brown body," and the experimentally treated young polypides gave rise, when they degenerated, to a brown body which was coloured blue. The active cells of the budding tissue are not normally charged with excreta, and they readily take up the experimental pigment, which is not found in the older buds or in polypides which are about to degenerate.

The excretory inclusions of the budding tissue may be derived directly from the water with which it is in contact. In other cases, this tissue showed no colour, or very little, after being taken out of an indigo-carmine solution, but after forty-eight hours in clean water the budding zone of *Electra pilosa* showed a faint coloration, and after seventy-two hours a deep colour. This appears to be because the phagocytes, or wandering cells of the body-cavity, take up the pigment and carry it to the budding tissue, by which it is ultimately excreted. In another experiment the stomach of buds not yet ready to protrude their tentacles was blue, but, two days later, some of these buds were protrusible polypides and had

uncoloured alimentary canals (having evacuated their excreta), while others had become bluish brown bodies. Marcus considers that excretion by the alimentary canal had saved many polypides from degeneration. When the budding zone had taken up pigments from the outside water direct, the newly formed buds degenerated.

Marcus is completely in favour of the view that the formation of a brown body has an excretory significance. During the formation of this structure, the parts which belong primarily to the polypide degenerate first. The retractor muscles thus share the fate of the alimentary canal and of the tentacles. But while this happens the zoœcium remains alive, and such structures as the occlusors of the operculum and the parietal muscles are at first unaltered. When the formation of the new polypide-bud is sufficiently advanced the old zoœcial musculature is gradually replaced by new muscles.

Unfavourable conditions may result in the formation of brown bodies. This may happen at temperatures which are too hot or too cold, with alterations of salinity, in the presence of an excess of sediment, or when an egg is developing in the zoœcium. In *Farrella repens*, in which the zoœcia are given off independently from a creeping stolon, degeneration may take the form of the loss of entire zoœcia, with their contents, to be replaced by the budding of new zoœcia from another part of the colony. Marcus has ascertained (1926[2], p. 50) that the " variety " *elongata* of this species, in which the stalk is specially long and the rest of the zoœcium is small, can be produced experimentally by unfavourable conditions. The normal number of tentacles, in both *F. repens* and *Electra pilosa*, can be reduced by similar methods.

(b) *Entoprocta*.—A process comparable with the loss of entire zoœcia in *Farrella* occurs in the Entoprocta, which, in spite of the contrary opinion of Marcus and Borg, I continue to regard as a group of the Polyzoa. The periodical loss and replacement of the complete calyx in the Pedicellinidæ has long been known. Cori (1929, p. 41), who has recently published a valuable general account of the Entoprocta (for which he has rather unnecessarily proposed the name Kamptozoa), suggests that this is a normal process of rejuvenation and that it occurs when the activities of the gonads are exhausted. He states that the colonies of the Pedicellinidæ are thus able to remain in a sexually mature condition throughout the greater part of the year. Nasonov (1926) has observed a remarkable adaptation of this process to the unusual conditions in which he found a member of this family. The River Tchernaia retchka flows into the Bay of Sebastopol, and *Arthropodaria kovalevskii* occurs in it about a kilometre from its mouth, but was not found at the actual

mouth or in the Black Sea. In the part of the river inhabited by the Polyzoon, the salinity in August was between 14·48 and 17·70. In the summer the river becomes almost dry and its salinity augments. In the autumn, after the rains, it may become almost fresh (salinity 1·5 in December). Specimens found on October 7 had completely lost their calyces, suggesting that they had probably been thrown off in the autumn and that the animal hibernates in the winter without them. All that were examined in January were without calyces, and the water was perfectly fresh. Regeneration of the calyces was proved experimentally to occur when the salinity increased. Placed in fresh water, the calyces if present fell off; replaced in salt water of a suitable strength, they were regenerated, but not if the water remained cold. Specimens without calyces were collected on January 27 in fresh water. On increasing the salinity to the proper amount, by the addition of sea water and keeping the specimens at 13°–15° C., calyces were regenerated by February 10—a date which is earlier than the period when regenerated calcyes could be found in the river.

(c) *Phylactolæmata*.—In the Gymnolæmata the formation of typical brown bodies seems to be universal, but in *Farrella* there is no periodic formation of these structures in the same zoœcium, and Marcus states (1926[2], p. 25) that degeneration of the polypide is always followed by complete loss of the zoœcium, as described above (p. 146). In the Phylactolæmata events follow a different course. Degeneration of the polypides occurs, but new ones are not formed in the same place. In *Cristatella* (Marcus, 1926[3], p. 288), when an old polypide degenerates it is rejected from the colony by the constriction off of a part of the common body-wall which contains it. New polypides are developed at the lateral margins of the colony, and not near the middle, where the older ones are situated (Marcus, 1925, fig. 38, p. 38). There is thus, at all times in this genus, a progressive increase in the size and age of the polypides from the lateral margins to the median line of the colony. In other instances, as in *Plumatella*, the new bud may develop close to the polypide which has degenerated, but these events can be more easily observed in aquarium cultures than in Nature. Colonies of *Cristatella* suffering from want of food were observed to lose their polypides and to evacuate the resulting brown bodies (Marcus, 1926[2], p. 393).

IV. The Taxonomic Studies of Messrs. Canu and Bassler.

The investigations so far noticed have been concerned with the Biology of the Polyzoa. A much larger amount of the

recent work on this Phylum has been connected with the systematic side of the subject, and in this connection the contributions of Messrs. Canu and Bassler stand out from those of all other authors. The number of memoirs which have been published by these investigators during the last few years is quite extraordinary, and their industry deserves the greatest admiration. They have described new genera and species in a profusion which has not been approached since the time of D'Orbigny, and they have placed the nomenclature of the Gymnolæmata on an entirely new footing.

In one important respect Canu and Bassler have rendered a service which entitles them to the gratitude of other workers in the same field. Several of their recent memoirs (1920, 1923, and 1929) contain, in addition to numerous original illustrations, a very extensive series of faithful reproductions of the figures of other authors. The great majority of the genera of the Cheilostomata and Cyclostomata have been included, and representative figures of them have been published. A worker on Polyzoa who possesses these three monographs is in a position to consult an immense number of figures, the originals of which can only be found by referring to hundreds of separate papers published in many journals or monographs. The assistance thus given to students of the group is of the greatest practical value.

It is an ungrateful task to criticize work so devoted and so genuinely useful. But it is obvious that various recent investigators have been a little too ready to assume that the wonderful amount of information which is to be found in the monographs of Canu and Bassler can be accepted without question. It seems to me necessary to say that the conclusions stated in these important works ought not always to be made use of without an examination of the evidence to be obtained from the writings of other authors. Borg (1926, pp. 468–470) has published a general criticism of them with which I am completely in agreement. This refers specially to the Cyclostomata; but as I have been concerned more particularly with the Cheilostomata I leave my own criticism as I originally wrote it, while admitting that many of the points to which I take exception have already been well brought out by Borg

In order to understand the principles on which these authors have based their classification (which is often revolutionary), it is desirable to go back to Canu's 'Revision des Bryozoaires figurés par D'Orbigny' (1900, pp. 346–348). We are there informed (p. 346) that a classification cannot be based on organic peculiarities which have not a physiological signification clearly understood. Every family must be based on an anatomical character common to all its members and fixed in an uninterrupted sequence of descent (p. 347). The

variations of this character serve to distinguish the genera. Specific characters are difficult to appreciate, but a species cannot be really known unless all its variations and all its organs are known (p. 348).

The principles of classification were restated by Canu and Bassler in their 'Synopsis of American Early Tertiary Cheilostome Bryozoa' (1917, pp. 7, 8), and again in their larger monograph 'North American Early Tertiary Bryozoa' (1920, pp. 70, 71). The passages quoted below are taken from the more recent work, but the two memoirs are substantially identical in their statement of principles :—

"Form is only the result of functions; therefore in the study of the morphological variations of the organs we now substitute that of their physiologic functions. Our studies are therefore always directed towards the discovery of functions which modify the skeletal form.

"*Family*.—All the species which have the same larval form have the same lineage and belong to the same family; therefore the family is characterized by its larval system. The ovicell in which the larva develops is necessarily in rapport with it, and a knowledge of its structure gives the essential characters for readily interpreting the physiological utility of the morphological and skeletal variations.

"*Genus*.—A really natural genus differs from another genus only in possessing a different function and not † in the different form of any skeletal part. The essential functions common to all bryozoa without exception are :

"1. Passage of eggs and escapement of the larvæ (=rapport of the operculum and the ovicell).

"2. Hydrostatic system and extrusion of the polypide (=form of the aperture and rapport of the operculum with the compensatrix).

"3. Calcification and chitinization (=nature of the skeletal part and of the frontal considered as immediate deposits of the endocyst).

"We have rigorously followed this principle in the establishment of our new genera.

"The function of the avicularia and onychocellaria is not known, but it can not be common to all bryozoa since many species are deprived of these structures; they therefore can not furnish good generic characters.

"*Species*.—All the morphological variations and all of the characters of adaption are specific characters. They are

† "not" does not occur in the 1917 version—a difference of some importance.

always utilized without method because we are ignorant of the life of bryozoa."

In 1900 Canu thus maintained that a family must be based on an anatomical character, but in 1917 and 1920 Canu and Bassler substituted a physiological basis of classification. Even if the functions of all the organs were known, few systematists would admit that physiology can be used as a better guide to affinities than morphology. The older classifications contain innumerable examples of mistaken associations of animals due to a similarity of function in certain organs. It is morphology which enables the naturalist to distinguish between the fore limbs of a Cetacean and those of a fish, or between the gills of a Mollusc and those of a Crustacean. But even if it were admitted that a natural classification ought to be based on "physiological functions," the difficulty of applying this principle would be insuperable in the present state of knowledge, because the functions of many structures are not satisfactorily known.

In their statement of the characters to be used in establishing a family, Canu and Bassler give some indication of the way in which the function is to be ascertained—"a knowledge of its structure gives the essential characters for readily interpreting the physiological utility of the morphological and skeletal variations." It is clear, from this and many other passages which might be quoted, that the physiology of Canu and Bassler is not that of observation and experiment, but that it is a physiology of inference.

It might have been supposed that these authors would have made full use, in their later publications, of the admirable physiological work of Marcus and others. This they have not done. Their conclusions as to functions, which they have drawn from the observed facts of structure, may in many instances be described as highly improbable, and I justify this statement by the following examples of the results of the method they have adopted.

The Cheilostomata include a number of genera and species characterized by forming discoidal or conical colonies which are not rigidly fixed, in the adult condition, to any substratum, and indeed, in many cases, appear to be quite free, without attachment of any kind. The mode of life of these colonies has been the subject of much discussion, and the evidence at present available is quite inadequate to settle definitely the doubtful points. In the great majority of these species the zoœcia are confined to the convex surface, and there are none on the other surface, which is usually flat or concave. *Conescharellina* is one of these genera, and, as its name suggests, its species are usually distinctly conical, with a flat "base." It had long been assumed that the colony rested on its flat surface, but more recently this view has been disputed.

Whitelegge (1888, p. 347) † stated that he had examined living specimens of *Bipora philippinensis* (now placed in *Conescharellina*) and had found that the colonies attached themselves to other objects by means of a pair of tubular filaments originating on either side of the colony about midway between the margin and "the summit on the upper surface." I find no evidence in his paper as to the attitude of the colony during life, except the word "upper," as quoted above, and this seems to imply that these colonies, while alive, were resting on their flat base. It should not be possible to state, as has been done, that Whitelegge's published observations assisted in disproving the conventional view that *Conescharellina* rests on its flattened base when alive.

A good many years later Maplestone (1910, p. 3) expressed the opinion that "the conical forms in their living state have the base uppermost," and that the filaments described by Whitelegge afford "a clue to the manner in which the conical forms manage to live with their bases upwards." He was uncertain whether they hang downwards from some foreign object or whether they retain their position, point downwards, by being anchored by the filaments to the ground. He considered his opinion proved by the fact that certain specimens have a coral growing on their bases, and he says that it is impossible that a colony thus provided could rest on its base because the delicate tentacles of the coral would then be crushed. Maplestone believed that certain peculiarities of the orifice and operculum also supported his view of the attitude of the living colony.

Faura Sans and Canu (1916, p. 125, sep., p. 69) make the statement "Nous avons déjà établi que . . . tous les *Lunulites* vivaient la pointe en bas sous les frondes des algues." I have been unable to find any record of the evidence on which this assertion is based, but it is manifestly not completely accurate. Many of the forms referred to are only known as fossils, and their behaviour when they were alive cannot be definitely ascertained. I venture to doubt whether there is a single species in which these authors have really established the correct attitude of the discoidal or conical colonies during life. If the necessary proof exists it ought to be published, and I believe that this has not been done.

I have failed to find any evidence that is really conclusive with regard to the question at issue. Except for Whitelegge's very brief account I am acquainted with no observations made on living specimens, and in my judgment the matter should for the present be regarded as undecided. Canu and

† Whitelegge's original paper was reprinted in the 'Annals and Magazine of Natural History,' and I make use of the reprint in quoting him.

Bassler have no doubts on the subject. In one of their most recent memoirs (1929, p. 482) they make the statement "Species of *Conescharellina* live with the apex downward and the base upward (Maplestone, 1910)." They produce no evidence in corroboration of this assertion (although they mention Whitelegge), but they elaborate their inferences and state them as if they were indisputable facts. After indicating the difficulty of understanding how a cone can stand on its apex, they continue as follows :—" One hypothesis is possible to explain this apparent anomaly, namely that of rotation. The small colonies turn without ceasing around their axis and develop their costules in inverse proportion to the facilities which they find to operate this gyratory motion. . . . There is no life more strange than that of *Flabellopora* or *Conescharellina*. They escape the immovable substratum but at the price of a perpetual movement. One dances, the other turns . . . " ; and further, with regard to the second of these two related genera (p. 498) :—" The colonies of *Flabellopora* float freely . . . They are all experienced aquatic equilibrists . . ." and (p. 499) " Another movement is suggested to us by the symmetry of the colony and by the thinness of the edges, namely rotation around the axis. This rotation is partial ; the animal presents its border (the cross-section) to the current and can then oppose a certain resistance to it. Although very feeble, this resistance is sufficient to bring automatically diatoms to the entrance to the tentacles . . . They mount and descend without cessation. They are ravishing small dancers . . ." In the diagnosis (p. 480) of the Conescharellinidæ may be found " The colonies are free and floating."

Messrs. Canu and Bassler give no evidence that they have examined the behaviour of living colonies of Conescharellinidæ, nor do they quote any other author (except Whitelegge) who has been able to do so. In their remarks, quoted above, on *Flabellopora* they admit that their account of behaviour is suggested by the structure of the dead colony, but the supposed movements of the living colony are described with an assurance which could hardly have been surpassed if they had actually witnessed every detail.

In 1915 Canu described what he termed a colonial hydrostatic system, and its supposed nature is explained by Canu and Bassler (1920) on p. 60 and on p. 238, under *Lunularia*, as follows :—

" The larva ordinarily attaches itself firmly on a grain of sand. The ancestrula which is derived from it immediately gives rise to some closed hydrostatic zoœcia which by their lightness permit the zoarium to commence its growth by ascending away from the sand dangerous to its development. (Aborted zoœcia of D'Orbigny.) When in the vicinity

of algæ, the zoarium remains fixed under their fronds. When they do not offer sufficient shelter, the closed zoœcia transform themselves into perforated, calcified zoœcia which are radicular: the radicles then attach the zoarium to shells, stones, or small algæ. The zoarium continues to develop in a more or less widened cone and always with the apex below."

The diagnosis of the Conescharellinidæ (*ibid.* p. 622) includes the following statement:—"There is both a zoœcial and a zoarial hydrostatic system." In the explanation which follows, "hydrostatic zoœciules" are referred to and the "hydrostatic cavity" is illustrated by text-fig. 187 L, a reproduction of Koschinsky's figure (1885, pl. vii. fig. 11) of his fossil species (p. 68) *Kionidella excelsa*. The species is thimble-shaped, with a wide axial cavity, open at one end, the orifices of the zoœcia being on the outer surface. The supposed hydrostatic cavities of Canu and Bassler are very small spaces at the basal ends of the zoœcia, in the calcareous wall which lines the axial zoarial cavity. As originally described, each such cavity is connected both with a zoœcium and with the axial cavity of the fossil. Koschinsky thought they might perhaps be the remains of avicularia, but there does not seem to be much to distinguish them from the pores, or perhaps pore-chambers, which are so common in the calcareous skeletons of Cheilostomata.

Two of the statements made by Canu and Bassler in the passages quoted are based on definite evidence. The *zoœcial* hydrostatic system is the compensation-sac (see Harmer, 1930, fig. on p. 96), which has been proved to exist in so many of the Ascophora that it is believed to be present in all of them. As to the second statement, it has frequently been observed that the young stages of these orbicular or conical colonies may occur on grains of sand or other small solid objects. Most of the rest of Canu and Bassler's account is, to the best of my belief, entirely imaginary. No evidence that I know of has been obtained to show that a highly calcified colony, like that of *Conescharellina*, has the least power of flotation, nor has it been explained how this could be brought about. The use of the word "hydrostatic," in connection with the zoarium, seems to suggest a false analogy. In the case of the zoœcia of the Ascophora, water is admitted into the compensation-sac, not to alter the specific gravity of the zoœcium, but to permit the protrusion of the polypide. It is an arrangement to avoid an alteration of the volume of the contents of the rigid body-wall—to compensate, in fact, for the emergence of a substantial part of the polypide when the tentacle-sheath is evaginated and the tentacles are protruded. The admission of water into the "hydrostatic" zoarial cavities could have no appreciable effect in altering the specific gravity of the colony, since, indeed, these cavities are presumably

always filled with fluid or living tissue. Even if gas could be secreted into them (for which there is not the least evidence), they are apparently too small to produce the flotation of the colony. Is it necessary to remark that a dried colony of a calcareous species is often observed to float, because its zoœcia are unnaturally filled with air ?

But it is not merely in their interpretation of the free discoidal or conical colonies that Messrs. Canu and Bassler state their inferences as if they were facts. In discussing the occurrence of *Crepidacantha poissonii* in the Panama region (1930, p. 34), they state that "The large migratory fish have transported its larvæ across the Pacific to the Hawaiian Islands and Tahiti, and even farther." The species in question has ovicells, and it is a fair inference from a number of known facts that the life of the larva, in species thus provided, is very short, probably not exceeding twenty-four hours. No suggestion is made as to the way in which fishes could transport larvæ of this kind. They might be effective in distribution if the larvæ of Polyzoa commonly fixed on their skin, thus producing colonies from which other larvæ could be liberated at different points in the migration of the fish. The slimy skin of most fishes is probably not suitable, however, for the fixation of such larvæ, and, unless evidence can be produced that Polyzoa actually grow in this situation, the agency of fishes in distribution must be considered questionable. Cantor (1841, Trans. Zool. Soc. ii, p. 309) found great numbers of colonies of a "*Cellepora*," circular in form and about 2–3 mm. in diameter, on the skin of a pelagic serpent, *Hydrophis gracilis* †, in the sea near the Gangetic Delta. He stated that these snakes renew their skin very frequently and that their "parasites" are thrown off as often as the skin is changed. It would thus appear that pelagic snakes are not likely to be in a position to carry Polyzoa any great distance. The individual snake figured by Cantor is in the British Museum, but its skin is quite clean, and it was obviously not one of those observed to be covered by Polyzoa and other organisms. The Cheilostome figured can hardly be considered recognizable, but it has some resemblance to *Actisecos regularis* as represented by Canu and Bassler (1929, pl. lxvi, figs. 1–4). Annandale (1912, Rec. Ind. Mus. vii, p. 147) has noted the occurrence of freshwater Polyzoa on the carapaces of Gangetic tortoises.

There is reason to believe that ships have been instrumental in the distribution of Polyzoa. Hentschel (1923) gives a list of about thirteen species found by him on ships examined in dock at Hamburg, and indicates the localities visited during the respective voyages and the months of their return. With

† Cantor's snake is referred by Malcolm (1926, 'Monograph of the Sea-Snakes (Hydrophiidæ),' p. 96) to *Hydrophis fasciatus* (Schneider).

few exceptions these are species common in the North Sea, and the larvæ which founded the colonies might have fixed on the ships in the neighbourhood of Hamburg. Taking into account the months when larvæ are produced in European localities (see pp. 125–130), the Polyzoa found on those ships which returned to port in the winter or early spring were probably brought some distance.

Certain statements made by Canu and Bassler with regard to avicularia may be noticed as further evidence of their tendency to asume what has not been proved. A colony of *Flabellopora* "bears also avicularia, the adventitious organs of oxygenation absolutely indispensable to zoœcial life" (1929, p. 496). In the Reteporidæ (*ibid.* p. 360): "The frontal avicularia by their incessant movements, facilitate the circulation of the water and drive the prey towards the tentacles in calm waters. . . . The large fenestrular avicularia drive the prey into the thousand and one meshes of the network and distribute the zoarial capture. . . . The oral avicularia are the guardians of the entrance to the compensatrix; they regulate the introduction of the minute drop of water at the moment of evagination."

The possibility that the avicularia are adventitious organs of oxygenation appears (Canu and Bassler, 1920, pp. 61, 64) to be based on a vague suggestion by Waters (1904, Belgica Report, p. 29), who does not mention respiration. The Polyzoa feed on microscopic organisms (see above, p. 135). These are brought to the mouths of the polypides, not by the avicularia, but by the ciliary currents produced by the tentacles, a statement for which ample evidence is given by Marcus and others. The activities of the avicularia might no doubt influence the movements of intrusive animals of larger size, but such animals do not constitute the food of the polypides. The interesting positive results of Buchner (see p. 136) with regard to one of the functions of the avicularia of Reteporidæ are not mentioned by Canu and Bassler.

As stated above (p. 149), Canu and Bassler maintain that a family must be established on the characters of its larvæ. In view of this statement, which appears elsewhere in their works, it is surprising that no attempt has been made to indicate the nature of the characters actually used, and still more surprising to find that larvæ are rarely mentioned in the diagnosis of a family. The reason for these omissions is, no doubt, that it would be impossible, in the present state of knowledge, to give the information required.

It cannot be assumed, as a general principle in Invertebrate Zoology, that the larvæ of all the species of a family are uniform in character. Instances will readily occur to every embryologist of conspicuous differences between the larvæ of species which appear to be closely related. But, putting

this consideration on one side, it may be enquired how far the generalization is applicable to the Polyzoa.

The principal sources of information, on this subject, are the works of Barrois (1877) and Calvet (1900). These records, and others scattered in literature, have been conveniently brought together by Borg (1930). It is necessary to realize that some doubt exists with regard to Barrois' determinations of species. It will be seen, for instance, by consulting his original account (p. 147), that his *Lepralia ciliata* is said to be synonymous with *Mollia vulgaris* of Smitt, and it thus seems improbable that the larva figured by him (pl. vii, fig. 7) is that of *Microporella ciliata*.

The figure has been reproduced by Hincks (1880, Brit. Mar. Pol. pl. lxxxiii. fig. 4) as a correct representation of the larva of *Microporella*, a genus which is of special importance in the system of classification. In discussing the characters of the larvæ, it is obviously essential to be certain that they have been correctly determined.

The choice of the larval characters for the establishment of families is singularly unfortunate. It is obvious that the larvæ of extinct Polyzoa must remain unknown, and the very numerous fossil genera and species are as much in need of classification as the others. But even if an attempt were really made to define families by the characters of the larvæ of recent forms, it would inevitably break down, because the larvæ have been examined in but a very small fraction of the known species.

It may be admitted without hesitation that in some of the larger groups of Polyzoa, as in the Cyclostomata and the Phylactolæmata, the larvæ, so far as they are known, appear to be fundamentally similar throughout the group. But is it justifiable to say, with Canu and Bassler (1929, p. 408), "A different larva corresponds always to a different family"? Their definition of the Electrinidæ (1920, p. 76) includes the statement, "Larva a *Cyphonautes*." Leaving on one side the fact that there is no justification for assuming that this was true of the larvæ of all fossil species included in the family, the most that can fairly be said of the recent species is that it may be true of all of them, and that there is a reasonable probability that this larva will be found to occur in a fair proportion of them. A *Cyphonautes* is definitely known in *Electra pilosa*, in *Membranipora villosa* Hincks, and in one or two other species (see p. 141), and this is almost as much as can be said with certainty about the species of Electrinidæ. But it is one of the most interesting facts in the embryology of the Polyzoa that this well-defined type of larva occurs also in more than one family of the Ctenostomata, as in *Alcyonidium albidum* (but not generally in this genus), in *Hypophorella expansa*, and in *Farrella repens*.

The same type of larva is thus found in several distinct families, belonging to two orders—a fact which is not in agreement with the generalization of Canu and Bassler. Not only is this the case, but, although *Alcyonidium albidum* has a *Cyphonautes* larva, *A. mytili*, as may be seen from the figure of Barrois (1877, pl. vi, fig. 20), has a larva so closely resembling those of certain Ascophorous Cheilostomata that it is hardly possible to point out any essential differences between them. For the Ascophorous larvæ reference may be made to the figures of Barrois, pl. vii, fig. 9 (*Lepralia pallasiana*), pl. viii, fig. 30 (*Schizoporella unicornis*), and pl. viii, fig. 32 (*Membraniporella nitida*) ; and these three species, with practically identical larvæ, are not placed in the same family by Canu and Bassler or by other authors.

There is a certain amount of evidence, however, that the larval form may be practically identical in related species. This is known to be the case with regard to the larvæ of species of *Scrupocellaria*, *Bicellariella*, and *Bugula*, which belong to the Division Cellularina, but are placed by Canu and Bassler (1929, pp. 29, 30) in three families. It would be difficult to establish differences between these larvæ, sufficient to justify the assertion that "a different larva corresponds always to a different family."

Perhaps the strongest case which has been made out for the utility of the larval characters in showing the affinities of genera is the resemblance of the larvæ of *Microporella impressa* (Barrois, 1877, pl. ix, fig. 1, as *Mollia granifera*) and *Hippothoa hyalina* (Barrois, pl. ix, fig. 4), which were placed in the same family by Levinsen (1909, p. 280) on account of this similarity.

I fully admit that the larval characters, if more fully known, might in many cases give valuable indications of affinity of genera and species, but it may safely be asserted that our knowledge is at present much too fragmentary to allow classification to be based on them. Without professing to have made an accurate calculation, I think it may be stated, without fear of contradiction, that the larvæ of recent marine Polyzoa are known in no more than a fraction of 1 per cent. of the described species.

It is clear, however, from a study of their work, that Canu and Bassler have not actually used the larval characters in defining families, in spite of the definite statements they have made to this effect. What they have really done is to make extensive use of the characters of the ovicells. "The ovicell in which the larva develops is necessarily in rapport with it" (Canu and Bassler, 1920, p. 71). It is by no means obvious, however, that this is correct. I see no reason whatever for assuming that the characters of a known ovicell are likely to give any real indication of those of the unknown larva. This conclusion may be illustrated by

Lepralia pallasiana, in which there is no ovicell—the embryo developing, as was shown by Calvet (1900, fig. on p. 266) in a membranous sac which opens into the vestibule of the fertile polypide. Its larva has been figured by Barrois (1877, pl. vii, fig. 9), and it resembles so closely those of other Lepralioid species in which the embryo develops in an external ovicell that it would be difficult, if not impossible, to establish any important differences between them. The use of the ovicells in classification appears to be perfectly legitimate, but I cannot agree that this is equivalent to utilising the characters of the larvæ.

In further illustration of the extent to which Canu and Bassler depend upon assumptions, I may mention their treatment of the family Phylactellidæ. In defining this family they state (1917, p. 67), "The larvæ are large and are more fully developed within the ovicell than is usual"; and, on the next page, "It [the larva] is quite distinct from all others in its form and its large dimensions, evidently characterizing a special family." Traced to its source, it is found that the first of the statements quoted above is taken directly from Waters (1900, J. Linn. Soc., Zool. xxviii, p. 91), whose remark refers to an Arctic species doubtfully indicated as ? *Phylactella labiata* (Smitt). It is clear, from an inspection of the original figures (pl. xii, figs. 3, 4), that Waters very imperfectly understood the structure of this embryo, and it would be impossible to decide from anything in his paper what are the respects in which it differs from other Lepralioid larvæ. The ovicells of this species, as figured by Canu and Bassler (1929, fig. 156, J, L, on p. 404), have peculiar features, which may fairly be taken into acount in classification. The words "evidently characterizing a special family" are no more than an assumption that the unknown larvæ of other species placed by Canu and Bassler in the Phylactellidæ have the unknown distinctive features of that described by Waters. No evidence is given by them that this is really the case, nor do they quote a single additional instance to prove that the characters of the larva of Waters are found in other species included by them in the family.

In the characters given for the definition of genera (see p. 149) the same tendency to assume what has not been proved can be detected. The first of these characters is "Passage of eggs and escapement of the larvæ." The method by which the egg passes into the ovicell was completely unknown until it was described by Gerwerzhagen (see p. 144), and Canu and Bassler do not refer to this description. Until further evidence has been produced, it cannot be assumed that the eggs are always laid into the ovicell in this particular manner, and the method of the "passage of eggs" cannot at present be made the

subject of any generalisation. But, as in other similar cases, the character which is actually used by Canu and Bassler is a different one, and in this instance it is the relation of the operculum of the fertile zoœcium to its ovicell. Although this is a relation which can be observed, it cannot fairly be assumed that it indicates exactly the behaviour of the polypide when the egg is being laid.

The statement (see p. 149) that the function of the avicularia is unknown and that these structures cannot furnish good generic characters is questionable in more than one way. The function of the avicularia is not entirely unknown (see pp. 134–136). Canu and Bassler have indeed contradicted themselves by giving a very circumstantial account of what they believe to be the functions of certain avicularia (see p. 155). A more substantial reason for criticism is afforded by the assumption that an organ whose function is unknown is useless for the definition of genera. The acceptance of this principle would deprive systematists of many of their best generic characters. It cannot be maintained even for the Polyzoa, in which the avicularia have been used with much success in defining families, genera, and species.

To sum up the preceding remarks, it appears to me that the most serious criticism which can be made of the work of Messrs. Canu and Bassler is their failure to make clear to their readers the distinction between observed fact and assumption. Their inferences, deduced from their observation of structural details, are usually given with as much confidence as their descriptions of definite characters of systematic value. They are usually stated, moreover, without any indication of the grounds on which they are based. A student of their writings is constantly faced with the difficulty of deciding whether a statement which appears questionable is founded on evidence or not. There is real danger in this method.

The question naturally arises how far the principles accepted by Canu and Bassler have led to a natural classification. The full discussion of this would hardly be suitable for a Presidential Address, and it would have to be very lengthy. I confine myself to one instance, which is of special importance since it affects all the families of the Cheilostomata.

In 1927 (pp. 9, 22) Canu and Bassler proposed a new suborder, Hexapogona, defined merely by the words "The ancestrula engenders six zoœcia regularly erect." It included Chaperiidæ, Orbituliporidæ, Conescharellinidæ and Mamilloporidæ, with two other families doubtfully referred to it. As originally introduced it appeared to be of the same taxonomic status as the suborders Anasca and Ascophora, and the effect of its introduction was to remove certain genera from these into a new suborder.

In 1929 the same grouping is adopted on pp. 25–36, where the families and genera are enumerated. But in the same memoir (p. 466), under Hexapogona, mention is made of a new suborder, Pentapogona, in which "must be classed all the other known cheilostomatous bryozoa." It differs from the Hexapogona in the "presence of five zoœcia about the ancestrula." If the Pentapogona really deserve this important place in the system, the group might well have been proposed in a formal manner and in a more conspicuous position. I have found it in only one other place in the memoir, on p. 516. It is here stated that "*Ascosia* belongs to the Pentapogona according to the figure of Jullien while *Mamillopora* has 6 cells around the ancestrula."

The suborder Pentapogona seems to have been introduced as an afterthought. It does not appear in the index, nor in the formal list of families and genera on pp. 25–36. In this list, *Ascosia* is found, with *Mamillopora*, under the Hexapogona. It is a minor matter that the suborder Pentapogona, as introduced, includes two other suborders, the Anasca and the Ascophora.

The important point to consider is whether the proposed innovation is supported by the facts, and I think the answer must be definitely in the negative. The expression "engenders," in the original diagnosis of the Hexapogona, can only mean that the ancestrula directly buds off the six zoœcia which surround it. The definition of the Pentapogona shows that the members of this group are to be recognised by the fact that the ancestrula is immediately surrounded by five zoœcia. Canu and Bassler clearly seem to imply that the zoœcia found in contact with the ancestrula are directly produced as its buds.

Shortly before his death, Waters (1924–1926) published a series of five papers dealing with the ancestrulæ of the Cheilostomata. I tabulate below the result of the examination of twenty-eight of his figures in which the number of zoœcia immediately surrounding the ancestrula can be definitely counted :—

TABLE 2.

Systematic position, according to Canu and Bassler.	Number of zoœcia in direct contact with the ancestrula.				Total number of observed cases.
	5	6	7	8	
Hexapogona (*Chaperia*) ..	..	2	1	..	3
Pentapogona (various) ...	3	11	8	3	25

This preliminary examination seems at once to negative the proposed classification, and a further enquiry gives little support to it. In the subjoined list I indicate in brackets the systematic position, according to Canu and Bassler, of certain genera (discoidal species) of which I have found definite records :—

Mamillopora (Hexapogona)	Ancestrula surrounded by six zoœcia (Waters, 1919, p. 93 ; in generic diagnosis).
Orbitulipora (Hexapogona)	Ancestrula surrounded by five zoœcia (Waters, *ibid.* p. 92, fig. 2 *b*, on p. 91).
Cupularia (Pentapogona)	Ancestrula surrounded by eight zoœcia (Waters, 1921, p. 401).
Selenaria (Pentapogona)	Ancestrula surrounded by eight or six zoœcia (Waters, *ibid.* pp. 401, 402).
Lunulites (Pentapogona)	

In the first of his papers on ancestrulæ (1924, p. 596) Waters states that in an encrusting Cheilostome the ancestrula typically buds off three distal zoœcia, one of which is median and two are in contact with it, on either side. He refers (p. 595) to Cumings's conclusion that the same method of growth occurred in *Fenestella*, " which seems also to be the case in other Palæozoic Bryozoa." The ancestrula (of the recent forms) has blister-like projections, developed on the inner side of its enclosing wall. Each of these, which Waters speaks of as " growth-chambers," is normally connected with a daughter-zoœcium, and they appear to be equivalent to the pore-chambers of Levinsen. In Waters's text-fig. A on p. 596 (but not in B, on the same page), a median proximal growth-chamber is present, in addition to the three distal chambers, and a proximal chamber is also shown in figs. 5, 6 and 8 on pl. xviii. Waters was a careful observer, and I should not like to dispute the occurrence of a proximal ancestrula-bud. It is certain, however, that this bud does not always occur, and, to the best of my belief, the most common arrangement is that in which the ancestrula has produced three distal buds. A case of this kind, in *Electra pilosa*, has already been described in this Address (pp. 122, 123, text-figs. 1, 2).

The typical encrusting Cheilostome colony is accordingly at first fan-shaped, consisting of the ancestrula and a few other zoœcia. By the reflection of the two edges of the fan, some of the zoœcia which were not budded off directly by the ancestrula come into contact with this, the primary individual ; and this method of growth is exemplified by various figures of Waters and by text-fig. 1 (on p. 122), which I have taken from Marcus. The reflected edges are not quite in contact with the ancestrula, which in this particular case might be said to be surrounded by seven zoœcia. An inspection of the figure will show that if the reflection had taken place in a slightly different

way, or if the zoœcia nearest the ancestrula had been rather larger, there might not have been room for more than five or six surrounding zoœcia. In any case, the zoœcium which occurs, in this figure, on the proximal side of the ancestrula is not a direct derivative of that individual, but is a remote descendant of its left lateral bud. The evidence derived from the figure and from other sources appears to show that the exact number of zoœcia in immediate contact with the ancestrula is a matter of trivial importance, and that there is no sufficient justification for basing two primary groups of Cheilostomata on this character.

So far as I have been able to ascertain, there is no conclusive evidence with regard to the earliest stages in the discoidal or conical colonies, and a mere count of the number of surrounding zoœcia is not enough to settle the matter. It may be admitted that the families Mamilloporidæ, Orbituliporidæ and Conescharellinidæ, which contain many of the genera having this zoarial form, are probably related to one another. The view that they differ widely from most other Cheilostomes also appears to be a reasonable one—and, so far, the grouping of these families, by Canu and Bassler, in a separate section of the Cheilostomata may very possibly be correct. The inclusion of the Lekythoporidæ in this assemblage perhaps depends on the evidence of *Actisecos*, in which they describe (1929, p. 516) six zoœcia "around the ancestrula." The reference of the Myriozoidæ to the same group seems much more doubtful. The Chaperiidæ, also placed in the Hexapogona by Canu and Bassler, are usually supposed to have Membraniporine affinities. Their number of zoœcia surrounding the ancestrula may be six, in some cases, but I think there is reason to believe that the number is not a fixed one and that it is likely to vary, within narrow numerical limits, in one and the same species. More evidence than has actually been produced is required to show that *Chaperia* is nearly related to *Conescharellina* and its allies.

Turning to another point, it is unfortunately impossible to accept all the diagnoses, of families and genera, which have been published by Canu and Bassler. It is a matter of common agreement among taxonomists that a genus cannot be properly understood unless it is known what is its genotype, and, so far, these authors do not differ from their colleagues. In their more recent works they have made a practice of mentioning the genotype, but it must not be assumed that the species thus indicated is the one which other systematists would accept. The reasons for selecting a particular species are seldom given, and a reader of these monographs is constantly left in a state of uncertainty as to

the validity of a choice. In the case of a monotypical genus, or in one in which a genotype was definitely indicated by the author of a new genus, reasons are unnecessary, and no question of uncertainty ought to arise. But, particularly in the case of one of the older genera which included species now distributed among other, usually newer genera, the selection is often one of great difficulty, and in all such instances it requires justification. Mistakes have often arisen owing to the fact that an author has indicated a genotype of a genus, in ignorance of the fact that some earlier author has made a valid selection of another species. In certain genera the genotype selected by Canu and Bassler is not a species which was included in the genus by its original author—and this is, of course, inadmissible. In other genera confusion has been introduced by selecting a species not included in the original introduction, but assumed in some other memoir to be synonymous with a species actually included. In all such cases it is essential to give a clear exposition of the synonymy of the species, in order to justify the selection.

A large part of the uncertainty with regard to the validity of many of the genotypes indicated by Canu and Bassler arises from the absence of sufficient explanation, or indeed of any explanation at all. But there is a more serious cause of complaint, in the fact that these authors do not consider themselves bound by the generally accepted Rules of Nomenclature. The following passages occur in their 1920 monograph :—" There should be no law of priority in these attempts at synthetic nomenclature " (p. 505); and " No author has regarded the family [Conescharellinidæ] in its entirety and the right of priority does not exist " (p. 622). With opinions of this kind so definitely stated, some doubt must be felt about the validity of all the genotypes indicated, unless the facts have been carefully verified and found correct. In one or two instances dissatisfaction has been felt by the authors with the original selection, and a different species has been substituted on a later occasion. Thus *Hoplocheilina* is a genus which was introduced by Canu in 1911, with the genotype (indicated) *Eschara osculifera* Reuss, 1872. In 1920 (pp. 237, 238) Canu and Bassler indicate *Hoplocheilina spectabilis* Canu, 1911, as the genotype, but they make no mention of Canu's earlier selection. The result is a new diagnosis, in which it is difficult to recognize much similarity to that given in the original introduction of the genus.

In proposing new genera Canu and Bassler have frequently disregarded the convention that a name should be based on the root of a classical word. It has been a common practice with them to introduce names composed of an entire Greek

word, followed by a Latin diminutive termination, such as *Leios-ella* and *Cystis-ella* (1917, pp. 48, 53). Genera ending in *-sella* are particularly regrettable, not only because they are etymologically incorrect, but because names such as *Catenicella* (compounded of *-cella*) are common in Polyzoa. In other cases they have taken even greater liberties with classical words, as shown by *Metroperiella* (ibid. p. 40) from μήτρα and περί ; and by *Schizemiella* (p. 47), which is derived from σχίζα and *emi*, an abbreviation of the word " peristomie," a term used in connexion with the orifice or aperture of a zoœcium. *Schizomavella* (p. 40) is partly derived from the same Greek word, but *mav* means that a median avicularium occurs on the zoœcium. *Schizolavella* (1920, p. 358) is similarly a genus in which the avicularia are lateral. The last two names are inconveniently alike ; and *Schizopodrella* (1917, p. 40) has too close a resemblance to the older genus *Schizoporella*, of which it is a variant. In 1927 (p. 11) we find *Trochosodon* (τροχός, ὀδών) and (p. 6) *Cigclisula* (κιγκλίς). The Greek aspirate is sometimes disregarded, as in " olocyst," a term repeatedly used by Canu and Bassler in the description of the calcified frontal wall of Cheilostomata. Many other such examples could be given, and there is no escape from the conclusion that the terminology of Polyzoa has been burdened with a large number of names on which a Greek scholar might be expected to pronounce an unfavourable criticism.

The plates published by Canu and Bassler are practically all reproductions of photographs. Many of the figures are admirable, but others have a confused appearance, and it may be almost impossible to recognize in them the characters given in the diagnoses, particularly as there is no explanatory lettering. This is most unfortunate if an unsatisfactory figure refers to a genotype, as is frequently the case. The want of adequate references is a serious omission in the text, and unless a reader is very intimately acquainted with the literature it is often difficult for him to trace them to their source.

I have permitted myself to call attention to some of the respects in which the work of Canu and Bassler may be criticized. But in doing so I hope that I shall not be supposed to underrate the value of their recent contributions to knowledge. I am full of admiration of the magnitude of the task they have accomplished ; and indeed their output since 1917 has been perfectly astonishing. They have produced the most complete and exhaustive account of the genera and species of the marine Polyzoa, recent and Tertiary, which has ever appeared. In 1927 they published their " Classification of the Cheilostomatous Bryozoa," containing an enumeration of the families recognized by them, with the names of the genera included in each, and followed by an

alphabetical list of nearly all the genera of Cheilostomes, with descriptions of many new genera. In 1920 and 1923 they produced two large and copiously illustrated monographs on the American Tertiary Polyzoa—both containing an immense number of figures from earlier authors, illustrative of most of the genera. The 1923 volume includes (pp. 209–243) a useful list of references to the literature of Polyzoa from 1899 to 1923. Until this date both authors had almost confined their investigations to fossil Polyzoa. Since then they have turned to the recent marine Polyzoa, and have written many important works, the most noteworthy of which are those on Morocco and Mauritania (1925, 1928), the Sandwich Islands (1927), the Gulf of Mexico (1928), Brazil (1928), the Philippine Islands (1929), the Galapagos Islands (1930), and Tunisia (1930). References to those not included in my list on p. 166 can easily be obtained from the 'Zoological Record.'

Messrs. Canu and Bassler have covered a larger area of the sea, so far as the Polyzoa are concerned, than any others have done, and they may justly claim to be leading authorities on the Phylum. In their Philippine Islands memoir (1929) they have reprinted the alphabetical list of genera which was published in 1927, almost without alteration; and the list of genera arranged under families, in the 1929 work, is also in the main identical with that of the same earlier memoir. The alterations which have been made in it bring it practically up to date, and this important monograph on a part of the world from which the Polyzoa had previously been only partially described is thus a work of special importance to investigators.

It is because these monographs by Canu and Bassler are indispensable to every worker on Polyzoa that I have ventured to criticize. I have felt that the good parts of the work will speak for themselves. But I have also felt that it is my duty, as one who has studied this subject for not far short of fifty years, to call attention to the fact that, although these monographs have in many ways simplified the task of future investigators, they do not relieve them of the necessity of looking into much of the evidence given in the writings of earlier authors. The grouping of families adopted by Canu and Bassler cannot be regarded as final. The genotypes indicated by them are not necessarily to be accepted without critical examination, and a diagnosis of a genus which is based on an invalid genotype is clearly in need of revision.

I trust that M. Canu and Mr. Bassler, with whom I have been in friendly correspondence for many years, will forgive me for the freedom with which I have criticized their results. I am confident that they will admit that all scientific work must

be subject to open discussion, and I trust that they will accept my assurance that I recognize the value of the services they have rendered to the study of the Polyzoa.

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OBITUARIES.

Thomas Fulton Bourdillon (1849–1930), who died at Bexhill on the 19th December, 1930, was born on the 1st May, 1849, at Palmaner in the Madras Presidency in South India, the second son of James Dewar Bourdillon, a member of the Honourable East India Company. He was educated at Marlborough College, and later studied Forestry in Scotland. He returned to South India in his twenty-second year to undertake coffee-planting in the hills of Travancore. After the South Indian coffee industry had been wrecked by a leaf disease, Bourdillon was about to enter the service of the Burma Timber Company when he was offered the post of Special Forest Officer to investigate the forest resources and possibilities of the Travancore State. He entered upon the duties of that office in June 1886, a happy event for both parties to the agreement. For the next three and a half years he was engaged in arduous exploration in the then almost unknown fastnesses of the dense evergreen and deciduous forests of that progressive State, to the detriment of his health. After completing the work, he was compelled to proceed to England on a holiday of recruitment. On his return in 1891 Bourdillon was appointed Conservator of Forests, an office he fulfilled with marked ability until his retirement in June 1908. His unflagging zeal, his upright character, and his unflinching impartiality carried him successfully through difficult and delicate situations; when the time came for him to hand over his office he left many friends and no enemies. He had created an efficient Forest Administration on a sound foundation. In addition to his duties as a Forest Officer, he was, from time to time, charged with those of a Special Magistrate and Justice of the Peace, and, for a short time, of Commercial Agent at Aleppy. Nevertheless, he found time to investigate the flora of Travancore and to make a considerable collection of herbarium specimens, upon which many new species have been founded, not a few of them first described by himself. He was elected a Fellow of the Linnean Society in February 1891. This special botanical interest, in which his careful and precise methods were of great value, culminated in 1908 in the publication of his book 'The Forest Trees of Travancore,' a work which is indispensable to the student of the flora of Travancore and the adjacent tracts. He also inaugurated the Forest Herbarium and Museum at Trivandrum, the headquarters of the State, which institution, however much it may be added to, will always retain the impress of his administrative ability and zeal.

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Bourdillon was a good rifle-shot, and in his earlier days competed with considerable success at Bisley. Interested in mission work, after his retirement he acted as honorary secretary to several missionary societies.

In 1892 he married Miss Mary Collins, daughter of the late Rev. W. H. Collins, for many years a missionary in China, and herself member of a Zenana Mission in Travancore. There were three children of the marriage, two sons (of whom the elder gave his life in the Great War) and a daughter.

CECIL E. C. FISCHER.

Dr. LOUIS DOLLO (1857–1931), who was elected a Foreign Member in 1920, spent most of his life as a conservator in the Royal Museum of Natural History, Brussels, and was also for many years a professor in the University of Brussels. He made numerous important contributions to our knowledge of extinct vertebrate animals, especially reptiles and fishes.

Dollo was born at Lille on Dec. 7th, 1857, and studied zoology, geology, and engineering in the University of Lille, where he graduated as a civil engineer. He was, however, most interested in natural history, and gladly availed himself of the opportunity of joining the staff of the Brussels Museum early in 1882. There he began at once to extend his curatorial work by researches on fossil reptiles, and he continued active palæontological research to the end. His last paper, on the carpus and tarsus of vertebrates, was published so recently as 1929.

When Dollo entered the service of the Brussels Museum, some of the remarkable skeletons of *Iguanodon* and other extinct reptiles, which had been discovered in the Wealden formation at Bernissart, near Mons, in 1878, had already been prepared for study, and others were still being extracted from the rock. He thus had the privilege of investigating this unique collection, and in a series of notes on *Iguanodon* published in the Museum Bulletin he not only made known many valuable new facts, but also discussed them in a masterly manner. Indeed, all his descriptive papers are full of new ideas based on the observed facts. He treated of Wealden crocodiles, turtles, and a newt, and he wrote an especially important series of papers on the Mosasaurians, of which many nearly complete skeletons have been found in the Upper Cretaceous rocks of Belgium. He also wrote on fossil fishes, and his paper on the evolution of the Dipnoi is one of the acknowledged classics of ichthyology. He always emphasised the importance of "ethology," or the study of organisms in relation to their natural surroundings. He also established the general principle that during evolution "an organism never returns exactly to its former state even if it finds itself

placed again in circumstances identical with those through which it has passed." He described this as the irreversibility of evolution, and published many illustrations of it, such as those contained in his papers on the feet of marsupials and on the secondarily quadrupedal dinosaurs. He never produced any exhaustive memoirs: he restricted himself to concise notes, which illuminated every subject with which he dealt.

On the occasion of his seventieth birthday, a group of Dollo's friends made contributions to the first volume of a new serial, 'Palæobiologica,' which was published in his honour by Prof. O. Abel in Vienna in 1928. This was only one of many marks of appreciation and esteem which he received from biologists outside Belgium. He was an honorary Sc.D. of Cambridge, and was awarded the Murchison Medal of the Geological Society of London in 1912. After a few months' illness, he died in Brussels on April 19th, 1931.

ARTHUR SMITH WOODWARD.

HEINRICH GUSTAV ADOLF ENGLER (1844–1930) was born on the 25th March, 1844, at Sargans, Lower Silesia, as the son of a shopkeeper. Having early lost his father, he was taken by his mother to Breslau, where he grew up in humble circumstances. After completing his education, he entered the Magdalenen-Gymnasium, a school of some note, where a friendly teacher encouraged and fostered his natural inclination for botany. Whilst still a boy, he acquired an astounding familiarity with the flora of the environs of Breslau and the near Sudetic Mountains, so that he attracted the attention of Rudolf v. Uechtritz, and through him, of Paul Ascherson and other rising German botanists of the day. In 1863 he matriculated in the University at Breslau, where he studied botany under H. R. Goeppert and Ferdinand Cohn. During his student years he became absorbed in the manifold and complex taxonomic problem of the genus *Saxifraga*, which he persistently pursued and developed through the whole of his life. The immediate result of this occupation was his dissertation "De Genere Saxifraga Pars i & ii historica et systematica," with which he gained his doctor's diploma in 1866. In the same year he obtained the post of teacher in natural history and mathematics at the Magdalenen-Gymnasium which he held until 1873. His professional duties fortunately left him sufficient leisure to extend and deepen his knowledge of plants by a wise combination of herbarium-study and frequent excursions, and by an extensive botanical correspondence. In 1868 he visited the Alps for the first time, travelling through eastern Switzerland to the Italian lakes. Through his work on *Saxifraga* he came into contact with August Wilhelm Eichler, who was then editing Martius's 'Flora Brasiliensis,' and

when in 1871 Eichler was appointed Professor of Botany in the University at Graz, he proposed Engler as his successor as "Custos of the Botanical Collections" at Munich under Professor Naegeli. In the following year Engler qualified as Privat-Dozent in the University of Munich, with which he remained connected until 1878. Whilst at Munich he completed his 'Monographie der Gattung Saxifraga' (1872) and continued to assist in the collaboration of the 'Flora Brasiliensis,' to which he had already contributed the Escallonieæ and Cunoniaceæ when still at Breslau—adding now the Olacineæ, Icacineæ, Zygophylleæ, Rutaceæ, Simarubaceæ, Burseraceæ, Ochnaceæ, Anacardiaceæ, Sabiaceæ, Rhizophoraceæ, and the Araceæ, on which he soon became the leading authority. The elaboration of these families for the 'Flora Brasiliensis' involved him in much morphological work beyond the limits of the Flora which either resulted in cognate papers in various periodicals or became eventually absorbed in later studies and publications.

When in 1878 Eichler, who had gone from Graz to Kiel, left Kiel for Berlin, Engler was chosen to succeed him in the chair of Botany in the University of the Baltic City, where he remained until 1884. Whilst at Kiel he wrote 'Versuch einer Entwicklungsgeschichte der Pflanzenwelt' (2 vols., 1879 and 1882), which is still the leading and most comprehensive account of the history of the floras of the world, although in many a detail outstripped by more recent research; and there he also founded the 'Botanische Jahrbücher' (1880), which he directed and edited through 62 volumes up to his death.

Then in the autumn of 1884 Engler went to Breslau, where the chair of Botany in the University had become vacant by the death of his old teacher Goeppert. This he held for five years, years of fruitful activity, which centred in the reconstruction of the Museum and the Botanic Garden and in the planning of a comprehensive encyclopedia of the vegetable kingdom on a modern and original basis. In the Botanic Garden he demonstrated, within the limits of the local climatic conditions, his ideas of a natural system in the arrangement of the plants and his concepts of the principal floral regions and subdivisions of the plant-world by the laying out of geographical groups. At the same time the contemplated encyclopedia materialised in 'Die Natürlichen Pflanzenfamilien,' for which he secured the assistance as co-editor of Karl Prantl, then Professor of Botany at the Forestry College at Aschaffenburg in Bavaria. The first part of the work appeared in 1887, containing the Palmæ by Oskar Drude. He soon gained the co-operation of a staff of fellow-workers that enabled him to complete the ambitious enterprise, as far as the Phanerogamæ were concerned, in the

short time of twelve years. Having already adumbrated the main features of his system in the arrangement of the plants in the Botanic Garden, he now for the first time outlined and explained them definitely in the 3rd and 4th parts of the Pflanzenfamilien (1887).

In March 1887 Eichler died at Berlin. For various reasons his post, the most important in Germany in the department of botany, remained unoccupied until the autumn of 1889, when Engler was appointed to succeed him. The importance of this appointment, in itself pregnant with opportunities for extensive scientific activity, was enhanced by two circumstances,—firstly the impending ripening of the plan to transfer the old Botanic Garden at Schöneberg, the administration of which was connected with the chair of Systematic Botany in the University, to more suitable quarters, and secondly the entrance of Germany among the great colonial powers of the world, which imposed new and wide tasks on the botanical centre of the empire. All this required a strong man as leader and organizer, and such Engler proved to be through his long term of office at Berlin (1889–1921).

Engler continued his scientific work on the lines he had already laid down for himself, under the most favourable circumstances, with the support of an able staff of official and non-official assistants and of a sympathetic government at a time when his country was quickly rising to the zenith of its power and wealth. When he entered on his new duties in Berlin, the account of the Phanerogamæ in 'Die Natürlichen Pflanzenfamilien' was approaching conclusion, whilst that of the Cryptogamæ, which was originally assigned to Prantl as editor, was still outstanding owing to Prantl's death in 1893; Engler now sought and obtained competent collaborators for this group, and he had the satisfaction of seeing the great encyclopedia completed in 1909. But he had also already prepared himself for a new enterprise, which was destined to develop within a short time into a boldly conceived and broadly planned survey of the vegetable world of the vast and largely unexplored German colonies, particularly those in Africa. The creation of a "Botanische Zentralstelle für die Kolonien" at the Botanic Garden, the starting of a standing series of contributions to the knowledge of the African floras ("Beiträge zur Flora von Afrika") in the 'Botanische Jahrbücher,' and the communication to the Academy of Sciences of Berlin of his great memoir 'Über die Hochgebirgsflora des tropischen Afrika,' all in 1891, heralded a stream of publications which in a short time tore the veil from a large part of the plant-world of Darkest Africa. In 1894 he laid before the Academy a paper on the vegetation of Usambara, until then a botanical terra incognita; in 1896 he published

'Die Pflanzenwelt Ostafrikas und der Nachbargebiete'; in 1898 he began the series of monographs known as 'Monographien afrikanischer Pflanzenfamilien und Gattungen'; in 1908 he launched his superbly ambitious 'Pflanzenwelt Afrikas,' which ended in 1925 as a grand torso. These are only some of the fruits of a stupendous activity in a field largely of his own creation and initiation. Others dealing with subjects of the most varied range, from individual species to whole families, are too numerous to be quoted in this place. They make up the bulk of more than thirteen pages of the bibliography appended to Diel's "Nekrolog" of Engler. The scope of many of these treatises and papers, although suggested by his African researches, extended far beyond the limits of that continent, as for instance his suggestive memoir 'Über floristische Verwandtschaft zwischen dem tropischen Afrika und Amerika' (1905). It is altogether characteristic of Engler's breadth of view that in dealing with problems of a limited scope he never lost contact with their wider and general aspects. They naturally entered into, influenced, and from time to time modified his broad concepts of the systematic, historical and geographical differentiations of the plant-world, and they found expression in many of his publications of the Berlin period. Of these I may quote his 'Syllabus der Pflanzenfamilien' which, originally intended as a guide for his lectures on special and medicinal-pharmaceutical botany (1892), soon assumed the rank of an independent standard work, which up to 1924 ran through ten editions, 'Die systematische Anordnung der monokotyledonen Angiospermen' (1892), 'Die Entwicklung der Pflanzengeographie in den letzten hundert Jahren und weitere Aufgaben derselben' (1899), 'Die Pflanzenformationen u. die pflanzengeographische Gliederung der Alpenkette' (1901), 'Grundzüge d. Entwicklung d. Flora Europas seit der Tertiärzeit' (1905), and 'Beiträge z. Entwicklungsgeschichte der Hochgebirgsfloren' (1916). But nowhere was his universal outlook more fully and more courageously realised than in 'Die Vegetation der Erde,' a collection of phytogeographical monographs which he started with Drude in 1892, and of which so far fifteen volumes have appeared, and in the monumental work 'Das Pflanzenreich (Regni vegetabilis conspectus),' which he edited on behalf of the Berlin Academy of Sciences since 1900. This has run until now to 96 parts, but, like the former, it has, under the stress of circumstances, most unfortunately come to a standstill.

Although the claims which the conception, organisation, and direction of work of this kind and extent and the personal participation in it involved might seem to be enough for the powers of a single man, they were added to by the duties of the administration and re-organisation of a great Botanic

Garden and of university teaching. It fell to Engler's lot to carry out the transfer to Dahlem of the Botanic Garden of Berlin, whose maintenance and development in Schöneberg had become untenable, and to establish it there along with a new institute that was to include a herbarium and a museum on lines adequate to the demands of a new and ambitious generation. The transfer, already suggested by Urban before Engler's arrival, was decided upon in 1897, and it was so far completed in 1910 that representatives of the prominent botanical institutions of the world could be invited to inspect the new establishment, which was indeed worthy of the great country it was to serve. It has been observed that Engler as class-room teacher did not rise to the rank he held as investigator and organizer. This may have been largely due to reasons of temperament and mind, but it may also be explained by the conditions inherent in the subject, which demands a broad foundation in herbarium and field-work, without which it is idle to teach in the class-room the principles of systematic botany and its cognate departments. Where Engler was able to build on such ground he was successful too, as the large school, which grew up around him and which has given so much to science, proves.

As Engler's botanical career began in that intimate contact with nature which accrues from frequent excursions in the field, so he never lost touch with her, and as the scope of his work widened he added to the excursions more and more extensive travels, which in the end took him round the world. He visited nearly all the European countries from the North Cape to the Mediterranean and from Portugal to Asia Minor and the Caucasus; he went to Africa three times, first in 1902–1903, when he crossed South Africa from Cape Town to the Transvaal and Delagoa Bay, proceeding afterwards to Usambara, the Kilimanjaro, and Uganda: then in 1905 on the occasion of the meeting of the British Association at Cape Town, when he extended his journey to East Africa, India as far as Darjeeling and Singapore, and lastly in 1913, when he paid a visit to South-West Africa. Soon after his return from Africa he left for China (Tsingtau) and Japan, and after a prolonged stay there he went by way of the Sandwich Islands to America to join the members of the Second International Phytogeographical Excursion in their visits to the Pacific States and the arid States bordering them. He returned to Europe travelling through the Alleghanies and the eastern States.

In 1913 the Linnean Society awarded to Engler the Linnean Gold Medal. In presenting it the President of the Society, Professor E. B. Poulton, in eloquent words gave expression to the appreciation of Engler's great services to the science of botany. I cannot do better than to refer to the President's

address. Engler had then entered on his 70th year. He was still in full vigour, and continued so until the fateful following year. After that he still held on to his duties, but the opportunities for development were sadly curtailed. Yet fresh contributions, some no doubt prepared in happier days, accrued to the 'Pflanzenreich,' the 'Pflanzenwelt Afrikas,' and the 'Botanische Jahrbücher,' and preparations for a new and emended edition of 'Die Natürlichen Pflanzenfamilien,' were made. Then at the end of March 1921, soon after the 77th anniversary of his birth, he retired from his professorship and from the direction of the Botanic Garden. His iron constitution, which had served him so well and so long, allowed him still for years to continue his studies in his old office rooms, and to superintend the publication of the 'Botanische Jahrbücher' and the 'Pflanzenreich'; but his marvellous powers having failed him at last, he gently passed away in his 87th year on the 10th October, 1930. He was buried under the trees of the Botanic Garden at Dahlem by the side of Georg Schweinfurth. O. Stapf.

Edward Arthur Fitz Gerald (1871–1930) was born in the United States of America, but of British nationality, and in due time became an undergraduate of Trinity College, Cambridge, where, tradition hints, he was one of the little band of ambitious mountaineers who, between visits to the Alps, kept their limbs in training by climbs in all manner of unauthorised ways up the faces of the college buildings, and produced as a *jeu d'esprit* 'The Roof-climbers' Guide to Trinity.' In 1893 a chance meeting in Switzerland with Sir Martin Conway led him to take climbing more seriously, and by way of apprenticeship he climbed "the Alps from end to end" (see Sir Martin's book with that title). Then he embarked on an undertaking of his own, proceeding to New Zealand with a Swiss guide, and was the second person to ascend Mt. Cook. Having done this, and having published his 'Climbs in the New Zealand Alps,' he prepared a more elaborate expedition to Aconcagua, in the Andes of Chili, and attracted to it Dr. Philip Gosse, son of Sir Edmund Gosse and grandson of Philip Gosse, the naturalist of the Devonshire coast. A full and illustrated account of the plants and animals collected by Dr. Philip Gosse and of all the work done appeared in 1899 in his 'Highest Andes.' With the appearance of this book his scientific work came to an end; he went into the Army and other occupations took his time. He retired with the rank of Major.

The Alpine Club has published in its Journal a portrait from a pencil-sketch made during the period when his interest in scientific exploration was most active. I. H. Burkill.

William Catton Grasby (1860–1930), whose death occurred on October 26th, 1930, at Guildford, W.A., was born in South Australia and educated in that State and in Europe. Early in life he entered the service of the South Australian Department of Education. As a result of a visit to Europe and America, made for educational purposes, he published a book entitled 'Teaching in Three Continents,' and later another, 'Our Public Schools.' Born and bred upon the land, it was the teaching of the practice and theory of Agriculture which particularly interested him. He owned and edited the 'Garden and Field' of Adelaide for many years, and from 1894 to 1896 he held the dual position of Head of Roseworthy Agricultural College and Editor of the Journal of the South Australian Department of Agriculture. An outstanding service to Australia generally was rendered when, in the capacity of Hon. Commissioner for the S.A. Government, he visited Europe and Asia Minor to study the vine-growing industry. Subsequently he visited Western Australia to report on that State's agricultural and fruit-growing possibilities. The direct consequence of that visit was his appointment as Agricultural Editor to the 'Western Mail,' a position which he filled until practically the end of his life.

He was elected a Fellow of the Society on the 5th April, 1894. George E. Nicholls.

Edward Morell Holmes (1843–1930), the well-known pharmaceutical botanist, who died at his home, Ruthven, Sevenoaks, on September 10th, 1930, had been a Fellow of the Society for 50 years.

He was born at Wendover on January 29th, 1843, and educated at the Grammar School of Boston, Lincs, and subsequently at Wimborne. At the age of fourteen he was apprenticed to a chemist in Cheyne Walk, and his industry brought him the distinction of being the youngest to pass the Minor Examination in pharmacy. After a period at Plymouth he returned to London. He passed his Major Examination with distinction in 1864, and in 1872 was selected out of twenty-four candidates as Curator of the Museum of the Pharmaceutical Society. Holmes was for a time also Lecturer at the Pharmaceutical Society's School, and served as botanical referee for the British Pharmacopœia Committee of the General Medical Council. He held the position of Curator of the Museum with conspicuous ability for fifty years, and his contributions to the 'Pharmaceutical Journal' are said to number about 600. He was awarded the International Flückiger Medal in 1897, and the International Hamburg Gold Medal in 1915. In 1900 he was President of the Pharmaceutical Conference held in London, when he took as the subject of his

address "The progress of Pharmacy during the Century." A full account of his work on behalf of the Society will be found in the obituary notices published in the 'Pharmaceutical Journal' 20th September, 1930.

Holmes was not only an enthusiastic botanist, he was an all-round naturalist and a born collector. In addition to his various herbaria, he had collections of Lepidoptera, Coleoptera, and marine and land shells. His published contributions to science apart from materia medica and allied subjects were, however, chiefly in the realm of the Lower Cryptogams. He had a good knowledge of British flowering plants, mosses, and Hepaticæ, but had a special and critical knowledge of lichens and marine algæ. Of all these groups he made collections, that of the seaweeds being probably the finest ever made in this country, and his lichen collection was excelled only by those of Leighton and Crombie. His mosses are now at Cambridge, the Hepaticæ at Cardiff, the lichens at Nottingham, and the marine algæ at Birmingham. All the field work involved in making these collections, such as the gathering of lichens and mosses on moors and mountains, wading for seaweeds at all seasons, and hunting for Lepidoptera until midnight, was carried out during vacations or after his official routine, and the amount of energy expended in the determination and arrangement of the material collected was amazing, and could never have been accomplished apart from the wholehearted co-operation of Mrs. Holmes. A further hobby was his garden, which was packed with a unique collection of medicinal plants and many others which he grew for their interest or rarity.

Holmes's enthusiasm did much to awaken the study of marine algæ in this country. It was he who stimulated the late A. E. L. Batters, with whom for a time he worked in co-operation, and the 'Revised list of British Marine Algæ' of 1890 was a joint publication. The continual discovery of additions to the British Marine flora, or of new species, attracted other workers, especially in the west of England, and with all these Holmes maintained an intimate correspondence.

In 1883 Holmes commenced to issue his 'Algæ Rariores Britannicæ' which came out in 12 fascicles of 25 sets each, containing in all 312 numbers, the last fascicle appearing about 1912. The accumulation of such a vast number of new or rare forms, which are now represented in the herbaria of twenty-five institutions where cryptogams are specially studied, was a remarkable and valuable achievement. Apart from this and the 'Revised List,' his published contributions to algology consisted mainly of notes or short papers.

Holmes's enthusiasm and tireless industry were coupled

with a cheerful temperament and affectionate nature. The writer well remembers meeting him in the spring of 1905 on the seashore near the Old Harry Rocks at Studland, Dorset. Holmes's delight at unexpectedly meeting a fellow algologist was intense, and he brimmed over with valuable information. That day's aquaintance ripened into a warm friendship which was maintained without a break.

Another characteristic was his exceptionally good eye for macroscopic characters, which enabled him to detect and realize differences at a glance which others would overlook. Occasionally these differences were given undue weight, and hence he was inclined to be a "splitter," and plants which are now regarded as "ecads" were to him good species. Differences of opinion, however, in such matters, never interrupted friendship.

After his retirement and the sale of his botanical collections Holmes occupied himself with pharmaceutical questions. The amputation of one leg below the knee at 78 years of age (the consequence of being run down by a motor) scarcely interfered with his work, and occasional visits to Sevenoaks during recent years always found him in his usual good spirits and busily occupied in his study surrounded by books and specimens. This vigour was maintained to the end, as was also his correspondence with Kew, which had been carried on uninterruptedly for about fifty years. A. D. Cotton.

John Hodgkin (1857–1930) was born in Birmingham in 1857, the second son of the late John Eliot Hodgkin, F.S.A., F.R.Hist.Soc. He was educated at Magdalen College School and University College, London, and became a partner in the firm of Howard and Sons, Ltd., of Ilford, manufacturing chemists, where he remained for some fifteen years. He retired early from his profession of chemist, and devoted himself largely to literary research, being a member of the Philological Society and the Bibliographical Society. The only work he published was 'Proper Terms,' a book dealing with the correct terms to be used of animals and so on, like the 'Book of St. Albans.' He took a great interest in philology for its own sake. In his later years he turned to the study of cookery and "Macaroni" literature, and collected a very considerable library on these subjects.

Outside his literary studies he was a noted connoisseur of English pottery, a prominent freemason (attaining Grand Rank), a Fellow of the Zoological Society, a Fellow of the Chemical Society, and a Fellow of the Institute of Chemistry. He was elected a Fellow of the Linnean Society on the 5th February, 1885.

He died at Reading on the 26th December, 1930.

A. E. H.

Frederick Lewis (born 18/7/1857, died 19/7/1930) had a useful but chequered career, marked by pluck and perseverance beyond praise. He was of the stuff of which great explorers are made, and was daunted by no privation or difficulty. Beginning life at fifteen as assistant to his father on a Ceylon coffee estate, he went through the disastrous days that followed the attack of *Hemileia vastatrix*. He hardly ever left the island afterwards, and ended his days there; yet he had a minute and detailed knowledge of the topography of London that would put to shame most Londoners. He served for 18 years in the Forest Department, acquiring a wonderful knowledge of the wild life of Ceylon, both botanical and zoological, of the ways of its people, and of the Sinhalese language, gifts that were to stand him in good stead when later he was appointed to the Land Settlement Department. He was perhaps the first man in Ceylon to plant rubber on a large scale (which he did for the Forest Department), and he lived to see the industry pass through all stages, from the heights of prosperity to the depths of over-production. A few years ago he published a fascinating volume of reminiscences that make a great appeal to older colonists. His scientific work was thoroughly carried out and with becoming modesty, though he suffered from the lack of proper training in youth. The name of Fred Lewis will long be held in remembrance by those who knew Ceylon at any time from 1880 to 1925.

He was elected a Fellow of the Linnean Society on the 1st November, 1894. J. C. Willis.

Mrs. Bella Dytes MacIntosh MacCallum was born in New Zealand. In 1908, after three years at Canterbury College, University of New Zealand, she took the degree of B.A., and in 1909 the degree of M.A., with Honours in Botany. After holding a National Research Scholarship from 1909 to 1911 she was appointed Assistant in St. Mary's College, Christchurch, and from 1913 to 1915 acted as assistant in the New Plymouth High School. During this period she obtained the degree of D.Sc. of the University of New Zealand with the thesis entitled "*Phormium* with regard to its Economic Importance." Coming to England in 1919, after a course in Bacteriology at the Cambridge Medical School she carried out research at the Mycological Department, University of Edinburgh, and published a paper on "Some Wood-staining Fungi" in 1920; she acted as Assistant in the Botanical Department of the University from 1920 to 1921. She became a Fellow of the Linnean Society in 1921.

In 1922 she proceeded to Australia with her husband, Dr. P. MacCallum, on his appointment as Professor of Pathology in the University of Melbourne.

Her death occurred at Melbourne in 1927.

MALCOLM WILSON.

The world is much the poorer for the loss of DONALD McDONALD, who passed away on Friday, February 27, 1931, aged 73 years. For some time previously he had been in failing health, and could not endure the crowds that frequented the horticultural exhibitions he so greatly loved to attend. His busy life was more or less divided into two separate portions. In the earlier part he was a seedsman, and for a long period of years held an important position with Messrs. James Carter and Co. at their High Holborn establishment. The later part of his life was devoted to journalism, but his pen was busy for some time prior to his retirement from the seed trade. His 'English Vegetables and Flowers in India and Ceylon' was published over forty years ago, and even so far back as 1895 he wrote a very useful and charming book on 'Sweet-scented Flowers and Fragrant Leaves,' and this was probably the book he was most proud of. A work that indicates a vast amount of care and research is his 'Agricultural Writers from Sir Walter of Henley to Arthur Young,' published in 1906, and covering a period of six hundred years; the extensive bibliography it contains must have entailed a very large amount of labour, a labour rendered easier, however, by the library he had acquired as the result of diligent and painstaking search. 'Fruit Culture and Utility' (1924), 'Some Farm Crops,' and 'My Garden Companion' (1905) are other works from this busy seedsman, whose flair for journalism eventually led to his retirement in favour of the latter occupation. As a chronicler of horticultural events and a writer on horticultural and agricultural topics Donald McDonald gained fame and position through his long association with 'The Daily Telegraph' and 'The Field.' This association increased his circle of friends, to whom he was ever ready to give that advice on horticultural and agricultural matters which his long and wide experience enabled him to speak and write of with authority. A portion of McDonald's library was purchased by the Royal Horticultural Society many years ago.

C. H. CURTIS.

JAMES MACDONALD (1855–1930) was born at Huntingtower, Perthshire, in 1855, and died at Harpenden, Hertfordshire, at the age of 75 years.

Completing his education at the Kinnoul Academy, Perth, he was immediately attracted to the study of the Gramineæ.

The importance of the subject, whether for agricultural pasturage, areas devoted to the playing of games, or for ornamental purposes in gardens or parks, was promptly realised by him, and with the characteristic, far-seeing determination of his countrymen fully, carefully, and accurately investigated. His ancestry was derived from those who, as farmers, had ever cultivated grassed spaces in the neighbourhood of the "Highland Line," and so the early choice of a specialised study of grasses was not entirely surprising. Early days were occupied in securing an exhaustive knowledge and collection of the Graminaceæ in his native district, and with the study of their habits in their natural environment, but this only at leisured intervals of not too frequent occurrence, because he found it essential to hold appointments to ensure that his investigations could proceed unhampered by lack of funds. Having thoroughly mastered the Scottish grasses and become acquainted with the majority of those living north with a knowledge of the subject (who in some cases kindly gave him letters of introduction to experimental stations, universities, and other authorities), he was able to visit England, Wales, Ireland, and parts of Europe, and examine much research work. Such research work never ceased to interest him.

Although an enthusiast on his chosen and much loved subject, he was not a narrow-minded specialist, but extremely broad in outlook. When rare trees and shrubs were being imported and planted in or near grassed areas he quickly acquired a firm knowledge of arboriculture, but this was always secondary to his accepted work.

Having acceded to numerous requests from various societies and the like for lectures concerning grasses, he decided to reside near London and definitely pursue grass cultivation professionally in an advisory and practical manner. Success followed this decision, and 'Lawns, Links, and Sportsfields' was published and thoroughly well received, and other publications were put forward from time to time.

The direction of a considerable organisation demanded his presence in foreign countries as well as at numerous places in the British Isles, because the knowledge acquired during his early days was greatly in demand. Quick to observe that the establishment of a grassed sward from seed was very greatly hampered and delayed by synchronous weed germination in the soil, a method was evolved by him, after considerable study and experiment, whereby the germinated grass seed could be placed on the site it was desired to grass, and, until this was established, weed growth was held in check; this proved a great economic boon to many, and patent rights were granted to the inventor. Other systems were introduced,

all of which it can be rightly said proved of great service to those wishing either for an improved crop or more pleasant recreation.

The selectivity and purity of grass seeds owe much to his efforts, and a great deal of interesting information concerning the fertilisation and hybridisation of grasses is due to his labours.

In the Great War he placed his services at the disposal of the authorities, being entrusted with the direction of grass camouflage and the establishment of grass to prevent drifting sand near coastal defence guns. He also accepted the invitation of the Food Production Board to lecture in Great Britain regarding fodder and other crops.

Of late years he passed to younger members of his family a large share of his professional responsibilities, but retained the governing direction of the organisation he had established and developed in a remarkably thorough and efficient manner until his sudden passing.

Of an unusually happy, cheerful, and generous disposition, it can with accuracy be recorded that James MacDonald was ever appreciative of life, of his numerous and widely scattered friends, and of the opportunities life presented to him of fully enjoying his work and study.

Honours were freely accorded him, but perhaps those most valued were the Gold Medal of the Royal Horticultural Society and his election to the Linnean Society, which took place on the 13th December, 1923. H. G. F. M.

William Carmichael McIntosh (1838–1931), who died at St. Andrews on April 1st, 1931, was the senior Fellow of the Linnean Society, having been elected into the Society on the 5th March, 1863. By his death in his ninety-third year a link is severed with that historic generation of naturalists whose pioneer labours in the development of Marine Zoology culminated in the 'Challenger' expedition. Professor McIntosh was born at St. Andrews in 1838; he spent his school days at the Madras College there, and from 1853 to 1857 was a student at the University. It was during his student days, under the influence of Dr. John Reid, Professor of Anatomy and Medicine, and with the encouragement and active assistance of his mother, to whom twenty years later he dedicated his monograph on 'The Marine Invertebrates and Fishes of St. Andrews' (1875), that he first became interested in marine life and laid the foundation of those studies to which so large a part of his vigorous energy was devoted. Continuing his medical studies, he passed from St. Andrews to Edinburgh, where he took his M.D. in 1860 at the age of twenty-two. His first published paper was the prize thesis which he had

submitted for his degree, "Observations and Experiments on *Carcinus mœnas*." The paper was dedicated to John Goodsir, Professor of Anatomy, and Geo. J. Allman, Professor of Natural History in the University of Edinburgh. It dealt chiefly with the structure and physiology of the nervous system of the crab. From 1860 to 1882 McIntosh was occupied in the practice of medicine, the greater part of that period being spent at Murthly, where he was appointed Superintendent of the Perthshire Asylum in 1863. At the same time he continued vigorously to develop his studies on marine animals, there being early papers on nudibranchs, anemones, echinoderms, and fishes, but by 1867 he had come to be recognised as a leading authority on the Annelida, and it was to this group that he remained attached. During these years he was in close touch with the work of the Committees of the British Association which were occupied in dredging investigations in the Shetlands and off the south coast of Devon and Cornwall, with which the names of Gwyn Jeffreys, Carpenter, Alder, Brady, Norman, Hincks, and Spence Bate are associated. As a direct result of the work of these Committees the cruises of H.M.S. 'Lightning' and H.M.S. 'Porcupine' were organised, to be followed by the 'Challenger' Expedition (1872–1876), and the Annelid collections from all these sources were entrusted to Professor McIntosh for examination and report. His reports on these collections culminated in the outstanding volume on Annelida, which constitutes Zoology XII. of the 'Challenger' series, published in 1885.

But during the years at Murthly, in addition to the collections received from all parts of the world, the study of the marine annelids of St. Andrews, based on living material, was continued, and expeditions were made from time to time to other British localities from the Shetlands and north Scotland to the Channel Islands in the south. On this side of the work he received splendid help from members of his family, especially from his sister, Roberta McIntosh (afterwards Mrs. Albert Günther), whose drawings in colour are so striking a feature of his publications. The first of these beautifully illustrated monographs was Part I. of the 'British Marine Annelids' published by the Ray Society in 1873–4, which dealt with the Nemerteans. This volume set a standard of excellence which, at the time of its publication, put its author at once into the first rank, and in many respects was probably his most important and valuable contribution to science. It dealt not only with the description and classification of a difficult group, but contained the results of a minute and comprehensive study of the anatomy and histology of individual species. It was followed in 1875 by 'The Marine

Invertebrates and Fishes of St. Andrews,' which was also strikingly illustrated with coloured plates.

In 1882 Professor McIntosh gave up his medical work and returned, at the age of forty-four years, to St. Andrews, having been appointed to succeed Professor Alleyne Nicholson as Professor of Natural History in the University, a position which he occupied for thirty-five years. In an introductory lecture delivered on November 13th of that year, and afterwards printed and circulated, he explained, perhaps more clearly than in any other of his numerous writings, his general attitude towards the study of marine zoology, the study which he had made, and was to continue to make, his central interest. Though much of his descriptive work, especially during later years, was done from preserved material, his first and fundamental outlook was that of the out-door naturalist, for the idea of a marine animal as a living creature, moving amongst the varied environments of the shore or of the deep-sea floor, or floating hither and thither under the influence of tide and current, which he had made his own during his early studies in St. Andrews Bay, never left him. It was this idea which led him, as he tells us, to dream, even in his student days, of a marine laboratory established on the shores of that bay, a project which he was to see realised in later years.

The St. Andrews Marine Station was, in fact, the first to be established in Great Britain, and was opened in an old wooden building in January, 1884, by the Fishery Board for Scotland, and placed under Professor McIntosh's direction. This building continued in use until 1896, when it was succeeded by the Gatty Marine Laboratory, the property of the University of St. Andrews, specially built and fitted for the purpose.

Soon after his appointment to the St. Andrews chair, circumstances arose which, to some extent, diverted his researches from the general study of marine invertebrates and from the special study of the Annelids to which he had come to devote most of his attention. In 1883 the Government set up the Royal Commission on Trawling, of which the Earl of Dalhousie was Chairman and Professor Huxley the scientific member. A sum of £200 having been provided by the Government "to be expended in scientific observations upon the results of the use of the beam trawl-net, and the distribution of the food-fishes taken by trawling on the various grounds frequented at different seasons of the year," McIntosh was appointed, on the 1st January, 1884, to conduct the observations. Ninety-three hauls of the trawl were made under his personal supervision on commercial trawlers, and his Report was ready by 1st November, 1884. By this work he became the pioneer of official fishery research in Great

Britain, and his interest in work of this kind remained to the end. He realised fully the difficulties of the task, and that future investigations must be organised on a broader basis. In the newly opened Marine Laboratory at St. Andrews, with the aid of a number of able young research workers, the study of the various aspects of fishery science was undertaken—the eggs and larvæ of fishes, the food of fishes, the plankton—indeed, nearly all branches of the work which have since developed were begun. From 1892 to 1895 Professor McIntosh served as the scientific member of the Scottish Fishery Board, being succeeded in that year by Sir John Murray. His general views on fisheries are summarised in his book 'The Resources of the Sea,' published first in 1898, with a second edition in 1921. The book is controversial, and its main conclusions have not been generally accepted by later writers, but it shows wide reading and a steady interest in the subject. Of more permanent value is 'The Life-Histories of the British Marine Food-Fishes,' published with Dr. A. T. Masterman in 1897.

In 1900 the publication of the monograph on British Marine Annelids was resumed, and was continued at intervals until Vol. iv, Pt. 2 completed the work in 1923. It is by this great Monograph and by the 'Challenger' Report on the same group that Professor McIntosh will be best remembered. There are doubtless defects of detail, but no systematist dealing with the Polychætes can proceed far without making helpful reference to both these works.

Looking at his life-work as a whole, extended as it was over a period of seventy years—for his labours and his interest in his subject continued with little loss of vigour after his retirement, in 1917, from the St. Andrews Chair—we cannot but admire the energy, the enthusiasm, and the sustained effort of a man who made the progress of science his ideal. The extent to which he continued to the end to read the most recent literature and appreciated the advances which were being made by younger men was surprising, and his encouragement was greatly valued.

Professor McIntosh was awarded a Royal Medal by the Royal Society in 1899, and the Linnean Society gave him the Linnean Medal in 1924. There can be no doubt that the most fitting tribute to his memory would be the rehabilitation of the Gatty Marine Laboratory at St. Andrews and its development as a University Laboratory on modern lines.

E. J. Allen.

On the 14th January, 1930, the Society learned with great regret of the death of Mr. Horace Wollaston Monckton, who had been Treasurer since the retirement of Sir Frank

Crisp in 1905. Mr. Monckton had done great service to the Society in the arduous office which he held, and always took an active part in the meetings, where his apt comments and occasional exhibits were highly appreciated.

Mr. Monckton was born in 1857, and was educated at Wellington College until he proceeded to study law. In 1880 he became a barrister of the Inner Temple, and so entered his adopted profession. From his earliest years, however, he had been devoted to field natural history, especially geology and botany, and he took every opportunity of following this pursuit. His old home was near Wellington College on the Bagshot Sands, and the first scientific task which he undertook was a detailed study of these sands and associated deposits to determine their distribution and relationships. His earliest paper was a summary of the results of this study, which was published by the Geological Society in 1883. While occupied with the geological work he met several young men of similar interests who became his lifelong friends, and when he joined the Geological Society and the Geologists' Association in 1882 he took his place at once among active minds. His sphere gradually widened, and by 1892 he had completed another important piece of research on the Gravels south of the Thames from Guildford to Newbury, which was also published by the Geological Society. His subsequent researches were more varied and less exhaustive, but there are numerous records of them in the ' Proceedings of the Geologists' Association ' and in ' The Geological Magazine.' For many years until the War he spent part of each summer in Norway, where he pursued both fishing and geology; and in 1902 he communicated to the British Association some notes on the geology of the Hardanger Fjord. He was especially active in the affairs of the Geologists' Association, of which he was President in 1902–04, and eventually became a Trustee. He led many excursions and published useful reports of them; for several years he edited the Association's ' Proceedings,' and to its jubilee volume, ' Geology in the Field,' he contributed chapters on Hampshire and the Bagshot District and on the Dorset Coast. Mr. Monckton was also for many years a member of council of the Geological Society, and from 1905 to 1909 he was Treasurer of that Society.

While occupied with field geology Mr. Monckton paid much attention to the flora, especially in its distribution over the different geological formations. He was thus led to become a Fellow of the Linnean Society in 1892, and the work of this Society was henceforth one of his chief interests. In 1916 he published a separate pamphlet on ' The Flora of the Bagshot District,' and in 1919 another on ' The Flora of the

District of the Thames Valley Drift between Maidenhead and London.' In his later years he studied the mosses of the same areas. Mr. Monckton indeed represented a type of amateur which is rapidly becoming more scarce, and his death is mourned by a large circle of devoted friends.

ARTHUR SMITH WOODWARD.

Professor SERGIUS GAVRILOVITCH NAVASHIN (1857–1930), a Foreign Member of the Linnean Society since 1911, was born in the village of Zarevshtshina, in the Saratov region on the Volga, on the 14th (2nd) December, 1857, and died at the age of seventy-three. His father was a doctor, the family estate having long since been lost. From the secondary school of Saratov he entered the Military Medical Academy in St. Petersburg in 1874. His father had died when Sergius was a boy of seven, and, beginning at a very early age, he largely supported himself by giving lessons to other schoolboys. In 1878 he went to Moscow University, where he completed the course in the Physico-Mathematical Faculty in 1881.

In 1883 Navashin was appointed Assistant in Botany in Moscow University, and in 1885 he received a similar appointment in the well-known Agricultural Academy of Petrovsky-Rasoumovsky near Moscow. He obtained the degree Magister Botanicæ at St. Petersburg in 1888, and began lecturing in the University in 1890. In 1894 his paper on the birch disease caused by *Sclerotinia Betulæ* was published, and he was appointed Professor of Botany at Kiev. In 1895 he obtained the degree of Doctor of Botany from Odessa, his thesis being a paper on the morphological significance of chalazogamy ("Ueber die gemeine Birke und die morphologische Bedeutung der Chalazogamie," 'Mém. de l'Acad. Imp. Sci. de St. Pétersbourg,' vol. xlii, 1894). Chalazogamy had been discovered by Treub in *Casuarina* in 1891, but Navashin added greatly to the knowledge of the subject by his series of papers describing the process in the birch, walnut, elm, and hazel.

This work was followed by his paper, remarkable for its time, giving a very detailed cytological account of the organism *Plasmodiophora Brassicæ*, the cause of finger-and-toe disease in cabbages, which Woronin had described in 1877. In particular he described, with surprising accuracy for its day, the process now known as protomitosis. About this time he also published a work on the mosses of Central Russia.

Navashin is perhaps most widely known as the discoverer of the process of double fertilization in Angiosperms. This important discovery was first announced at a meeting of the Russian Society of Naturalists in August, 1898 ('Bull. Acad. Imp. Sci. de St. Pétersbourg,' vol. ix, p. 377), the observations

having been made on *Lilium Martagon* and *Fritillaria tenella*. It was confirmed in the following year by Guignard. Many botanists were working on fertilization at this time, and in 1900 the process was verified in several other genera, while Navashin himself added *Juglans*, *Delphinium*, *Rudbeckia*, and *Helianthus* to the list in which it occurred.

In 1909-10 he published important papers in Vienna and Kiev on the nuclear division in the pollen tube and the self-motility of the male nuclei in certain flowering plants. These observations were largely confirmed by Blackman and Welsford.

In 1915 Navashin gave up the Professorship at Kiev and moved to Tiflis on account of his health. Here he worked in the Botanical Garden, which is situated partly on a hillside and has an entrance by a tunnel from the opposite side of the hill. It contains a stream with a high waterfall, and is devoted chiefly to the very interesting Caucasus flora, but becomes very dry in summer.

Professor Navashin was elected a Foreign Member of Kungl. Vetenskaps Societeten, Upsala, in 1917, and a member of the Russian Academy in 1918. He returned to Moscow in 1923 on his appointment as director of the Timiriazev State Institute for Biological Research, which was devoted chiefly to investigations in plant cytology and genetics. It was here that I first met him in 1926. At this time he had trained his son, Dr. M. Navashin, as an accomplished cytologist and geneticist—by no means one of the least of his scientific achievements. In his work ("On the Nuclear Dimorphism in the Root-tips of *Galtonia candicans*" (Russian), 'Bull. de l'Acad. Sci. de St. Pétersbourg,' vol. vi) on the chromosomes of *Galtonia candicans* in 1912 Navashin had already developed a technique in which the exact details of structure, such as the presence of satellites and constrictions, were clearly brought out. In a memorial volume to Timiriazev (1916) he published a paper on the internal structure of chromosomes, and in a similar volume to Borodin (1927) this subject was further discussed. He attended, with his son, the International Genetical Congress in Berlin, 1927, and was elected its President. At this time various workers in his laboratory were already obtaining important results in the study of the structure of chromosomes in *Crepis*.

The term satellite, or trabant, was introduced by Navashin in the 1912 paper for the tiny granule which some chromosomes display attached to one end by a short thread. He also concluded, contrary to Strasburger, that the pairing of chromosomes in somatic mitoses, at least in *Galtonia*, was no more frequent than would be expected according to the laws of chance. In a paper which should be more widely

known ("Zellkerndimorphismus bei *Galtonia candicans* Des. und einiger verwandten Monokotylen," 'Ber. d. d. bot. Gesells.' vol. xlv, pp. 415–428, pl. 1, 1927) Professor Navashin repeated and extended his earlier work with *Galtonia*. He showed in this paper that while one pair of chromosomes has a satellite attached by a thread, all the others have a terminal darker staining body ("Leitkörperchen") which is adherent to the chromosome and not separated from it by a thread. He concluded that the satellites represent a terminal chromomere, and that they play some rôle in the attachment of the spindle fibre to the chromosome.

More remarkable still, he found that in some plants of *Galtonia* the mitotic figure shows constantly the two satellites of unequal size (a large and a small), while in other plants of less frequent occurrence both satellites are of large size. This is the nuclear dimorphism referred to in his title. By growing plants from seeds of the type heterozygous for large and small satellites he showed that this difference was inherited, and that plants with a pair of small satellites did not exist because such embryos failed to develop. Moreover, he showed that in the prophase of mitosis the satellites are at first attached to the nucleolus, later becoming terminally attached to a particular pair of chromosomes, and that in the occasional tetraploid cells there are four such bodies attached to the nucleolus. All these points were clearly demonstrated during my visit to Moscow in 1926. In his paper, Navashin showed that a similar nuclear dimorphism exists in *Muscari tenuiflorum*, some plants having the symmetrical condition with two large trabants, others the asymmetrical condition with a large and a small.

Although already advanced in years, Navashin accepted a new post in Leningrad, in 1929, to act as Director of the newly organized cytological laboratory of the Academy of Science; but unfortunately he died on December 10th, 1930, from an attack of influenza.

Professor S. Navashin's published papers number about eighty, which is not a large aggregate for a long life, but he was unhurried in reaching his conclusions, and many of his papers mark distinct advances in technique and in conceptions of nuclear detail. His early work was in bryology and plant pathology, but his name will always stand as the one who first successfully solved the enigma of double fertilization in flowering plants. Later he became interested in problems regarding the organization of the hereditary nuclear material in plants. His discoveries concerning the organization of the nucleus are fundamental, and their importance has not yet been fully recognized.

Professor Navashin was a man of kindly manner and

a master of clear statement. He spoke German fluently, was very unassuming, and was given to helping forward his younger colleagues and students. He guided the youngest beginner in research without any assumption of superior knowledge. He was a true cytologist, always seeking improved methods of technique and the resolution of finer details in cell structure. R. R. Gates.

Spencer Le Marchant Moore (1850–1931). By the death of Spencer Moore systematic botany has lost one who, by his careful and arduous work, added much to its development. For over thirty years he was attached to the Department of Botany, British Museum, as an "unofficial scientific worker," and except for an occasional visit to the Kew Herbarium and to the rooms of the Society was never to be seen elsewhere in recent years.

Spencer Moore, as he was always called, was born at Hampstead on the 1st November, 1850, and was the second of fourteen children. He was originally intended for medicine, but after two years at University College Hospital, where he took his B.Sc. and gained a gold medal for Botany, he joined the staff of the Kew Herbarium in 1872, and took up systematic work with enthusiasm. His reason for leaving Kew was unusual. Always a little concerned about his health —the temperature of the Museum herbarium and draughts were a constant source of worry to him, and led to his usually retaining his hat—he considered that he needed a little exercise before attending the herbarium. Sir Joseph Hooker naturally objected to the walks being taken in official time. Moore was obstinate, and continued in his belief that he had no other course open to him. His resignation was not, however, quite so foolish as the story usually goes. His friend Henry Trimen (with whom he was associated from 1877 as assistant editor of the 'Journal of Botany') was appointed Director of Peradeniya in 1879, and Moore applied to the Office of Works, then the Department controlling Kew Gardens, for permission to be nominated for the vacant assistantship in the Museum. This was granted, and he was the successful candidate at the examination. The Treasury, however, refused to appoint him.

The chance of a government post being closed to him, Moore turned from systematic botany and took up physiology and cytology. He was handicapped in every way, but his 'Studies in Vegetable Biology' were published in the Journal of this Society (1885–92). Whatever their value at the present time, these investigations gave him an insight into many problems which others, including myself, found most useful in later years.

His return to systematic botany was due to his being appointed botanist to the Beckett expedition, which was prospecting in the Matto Grosso, Brazil, in 1901–2. His appointment was recommended by W. Carruthers, Keeper of Botany, and he worked out his large collection in the Department of Botany, publishing the results in the Society's Transactions (1895). This was a valuable paper, and was his most important contribution to systematic botany. He combined botany with gold digging in an expedition to the desert interior of Western Australia (1894–6). The financial and botanical results both left much to be desired, but he gave a useful account of the vegetation in the Society's Journal (1879).

In 1898 he was employed in the Department of Botany as unofficial worker, and continued so until his death. He worked principally with Australian and South American material, and usually undertook the investigation of the Gamopetalæ in the elaboration of collections coming to the Museum. As a hobby he was interested in Compositæ and Acanthaceæ. After W. Fawcett's death, Moore assisted A. B. Rendle with the 'Flora of Jamaica,' and had finished the Compositæ and made progress with the Rubiaceæ. His numerous papers were published mainly in the 'Journal of the Linnean Society' and the 'Journal of Botany.' He edited Lord de Tabley's 'Flora of Cheshire,' and saw Marloth's 'Flora of South Africa' through the press.

During the twenty years I knew Spencer Moore I found him always the most delightful of colleagues. He was often whimsical, but always downright in his opinion, both of men and matters. In 1866 he and a brother had founded the Hampstead Cricket Club, and he retained his interest in cricket; his comments on the Australian test matches always repaid one for purchasing a cricket edition. He had an extensive knowledge of English literature, and wrote (as Julian West) 'My Afterdream' (1900), a sociological romance which was a sequel to Bellamy's 'Looking Backward.' He also wrote a poetic drama, 'Aurelian,' which dealt with the subjection of Zenobia: the play was never produced, though it appealed to Beerbohm Tree. His fund of general information was extremely useful to his colleagues, and he was usually appealed to when difficulties of identification were encountered. In his later years he was self-effacing to an extraordinary degree, happy in his work and in the careers of his relatives—he was unmarried—and of his colleagues. He was cremated at Norwood Cemetery on the 18th March, 1931.

J. Ramsbottom.

Charles Edward Moss (1870-1930), Professor of Botany in the Witwatersrand University, died at Johannesburg on the 11th November, 1930, from hæmorrhage of the lungs as an after-result of a severe attack of influenza. After cremation, his remains were interred at Halifax.

Moss was born at Newton, near Hyde, Cheshire, on the 7th February, 1870, according to information supplied by his family; but, strange to say, he himself always spoke of having been born in 1872, and has written this date in a birthday book in the Department of Botany, British Museum. His father was a Nonconformist minister, and eventually moved to Halifax when Moss was about four years old. Here he had his schooling, and later became a pupil teacher. He could not afford to proceed at once to college after finishing his apprenticeship—he was the youngest of a family of six—and a further delay was caused by his having to undergo an operation for a pulmonary abscess in 1893. He entered Yorkshire College, Leeds, two years later and took the day training course, and obtained his B.Sc. in 1898. Older than the run of undergraduates, he benefited much from his association with L. C. Miall, J. Welton, and W. G. Smith.

Moss's stories of these early days were told and retold to me over a number of years; they showed that the young men of Halifax were ready to enter into any project which offered fun or civil good, and suggested that Moss himself owed his advancement to initiative and hard work. The Halifax Scientific Society attracted many of them, and Moss joined the botanical section in 1892. After his illness he spent more and more time in the field, and was active in helping his friend W. B. Crump with the 'Halifax Naturalist,' begun in 1896 for the purpose of publishing Crump and Crossland's 'Flora of the Parish of Halifax' as a supplement: Moss contributed a paper on "Why do flowers bloom in spring and winter" to the first volume, and later assisted in editing for a short time. Numerous notes scattered through the eight volumes (1896-1904) show his wide interest in botany.

After leaving the University he took up teaching at Bradford, and remained there until the beginning of 1901, when he was appointed to Sexey's School, Bruton, teaching botany as his main subject. Although there only a little over two years, he had a great influence on the boys, as I know from having had several of them as my contemporaries at Cambridge He left Bruton for a much less attractive position, with much evening work, at a Manchester Pupil Teachers' Centre, so that he could study for his M.Sc. and his Doctorate at Victoria University.

W. G. Smith had gone to Leeds in 1896 as assistant lecturer in Botany. He was intent on applying the methods of

vegetation-mapping initiated by his younger brother Robert, and realised that Moss, with his knowledge of the local flora, would make an excellent collaborator. They began their studies in 1898, and their results were published in 1903 as 'Geographical Distribution of Vegetation in Yorkshire.—I. Leeds and Halifax District,' which was illustrated by a coloured map. From this time Moss was for many years the real driving force in ecological investigations in this country. A number of botanists interested in mapping vegetation formed themselves into "The Central Committee for the Survey and Study of British Vegetation" in 1904. This was the forerunner of the British Ecological Society, and Moss played a prominent part in its activities. While in Somerset he began a study of the vegetation of the Bath and Bridgewater district which was published in 1907, and obtained for him his doctorate and the Back Bequest of the Royal Geographical Society, "for your important researches on Geographical Distribution of Vegetation in England, as embodied in your paper on the 'Peat Moors of the Pennines,' in the Journal [R.G.S.] for 1904, and in a paper on the 'Geographical Distribution of Vegetation in Somersetshire,' with map, published as one of the extra publications of the Society. You carried out this work at your own expense during your holidays."

Meanwhile he began to study the vegetation of the Peak District, usually spending Saturday or Sunday tramping over the moors. I retain happy memories of many of these excursions, always undertaken with a definite object, and nothing except snow acting as a deterrent. The resulting 'Vegetation of the Peak District' was published in book form in 1913, and is a definite land-mark in ecological studies in this country.

Moss's other main contributions to ecology were "The Fundamental Units of Vegetation" ('New Phytologist,' 1910), a collaboration with W. M. Rankin and A. G. Tansley on 'The Woodlands of England' (1910), "Ecology" in the 'Encyclopædia Britannica,' (1910), and sections and the classification of plant communities adopted in 'Types of British Vegetation' (1911).

In 1907 Professor Seward invited Moss to become Curator of the Herbarium at Cambridge. It meant some financial sacrifice, but the offer was too attractive for anything material to have undue weight. There was an immediate change in the atmosphere of the herbarium, and it became a live part of the Botany School. He now turned to taxonomy as his special study; this was mainly because of the material and the opportunities to hand, but there was also the fact that his friend A. G. Tansley had charge of the ecology courses, and this, I know, influenced him. His first contribution of importance

in taxonomy was on 'British Oaks' (1910), and this was followed by studies on the British Elms and on Salicornias.

I remember that early in our acquantanceship he had given me his opinions about students' floras, and had said that there was room for a new one. When he got settled at Cambridge he began to talk about producing one himself. After the University acquired E. W. Hunnybun's drawings the scheme was dropped for the more ambitious 'Cambridge British Flora.' The first volume (2) of this appeared in 1914 and the second (3) (edited by A. J. Wilmott) in 1920. If the work had been completed, many of the criticisms levelled against it would have been shown to be unwarranted. It was a big undertaking, and Moss was prepared to carry it through with or without assistance. The decision of the publishers to suspend publication was a big blow to him, not so much, I believe, because the project had not been carried through as that he felt that faith had been broken with subscribers and contributors.

When war broke out, Moss was anxious to join up. He saw very clearly what was involved, and after serving in the O.T.C. took up munition work. In 1916 he had domestic troubles; fortunately about this time he accepted the position as Professor of Botany at the South African School of Mines (afterwards the University of Witwatersrand).

Here he had the problem of building up a school of Botany "from the first brick," and succeeded in producing a department which was remarkable for its activity and progressiveness. He applied himself to a study of the flora of the Transvaal and beyond its borders, finding problems in plenty, and paying periodic visits to the British Museum and Kew to straighten out both determinations and nomenclature. His activity at this period was as great as at any part of his career, and it is lamentable that just as he was thinking of beginning to publish his results they should be lost to a great extent to South African botany. He intended to continue this work when he retired, and was despatching the duplicates of his collections to the British Museum for that purpose. He attended the Linnean Society regularly when he was in England, and occasionally gave a preliminary account of his results. He probably knew the Linnean and Smithian collections at one time only second to B. D. Jackson. He was elected a Fellow in 1912, and served on the Council 1914–17.

On re-reading a notice in the 'Journal of Botany' (Feb. 1931), I feel that I cannot express my personal relations with Moss better than by quoting from it:—

"I first met Moss in 1903, though I did not know that he was interested in Botany until the subject of his thesis was announced in a local paper during my first long vacation.

I called to congratulate him, and hearing that I was taking botany he suggested my accompanying him to the moors the next day. During the rest of the vacation we spent either Saturday or Sunday together, and thus began a friendship which continued unbroken till his death.

"He was a man of strong personality and decided opinions. He was fond of quoting the tag *suaviter in modo, fortiter in re*, though he often failed in its application, and not infrequently caused an uncomfortable liveliness at meetings. Many gained a wrong impression of him, some of his seniors regarding him as somewhat bumptious. Amongst younger men, on the other hand, he was very popular. They realized that he had missed much of what was his due by his apparent truculence, and admired him for his honesty of purpose as well as for his work; also for the help and friendship that he always extended to them. His knowledge of botany was as extensive as that of anyone I have known, and in the field he had that happy intuition which marks the true naturalist.

"For myself, I have lost my oldest botanical friend."

J. Ramsbottom.

Richard Vowell Sherring (1847–1931) was born at Bristol on December 23rd, 1847, and he died February 4th, 1931, aged 83, at Hallatrow, near Bristol. Early in life he showed a love of natural history and became especially interested in botany, entomology, and geology. Owing to an early breakdown in health, he spent a year in the south of France, where he began collecting specimens. On his return in 1868 he joined the Bristol Naturalists' Society, and studied geology under Sanders and Stoddart, and later under Sollas.

In 1873, after a severe illness, he was sent to the West Indies, and returned completely cured. He made four subsequent journeys, and did much collecting of plants and photography. The last trip extended to Barbados and up the Essequibo in British Guiana. He brought to England the first cocoa beans from Jamaica, which Messrs. J. S. Fry & Sons converted into chocolate.

The 'Journal of Botany', 1882, pp. 323–25, has an account of "Jamaica Ferns" by G. S. Jenman in which are three new species collected by Sherring, including *Polypodium Sherringii* Baker.

Another paper by G. S. Jenman in 'Journ. Bot.' 1886, pp. 265–74, on "Some Additional Jamaica Ferns," recorded *inter alia* a number collected "chiefly by my friend Mr. R. V. Sherring, who spent the past winter in exploring the less known parts of the island." Here was described a new tree-fern, *Hemitelia Sherringii* Jenm.

Sherring was invited in 1890 by the joint West India Exploration Committee of the Royal Society and the British Association to visit the island of Grenada, chiefly to collect ferns and orchids. His photographs were subsequently presented to Kew, where his ferns were worked out by J. G. Baker and the orchids by Rolfe. A set of the ferns was also presented to the British Museum by the West India Committee. There are some of Sherring's Jamaican specimens at both Oxford and Cambridge.

His collection of ferns from Grenada formed the subject of J. G. Baker's paper "On the Vascular Cryptogams of the Island of Grenada" in 'Annals of Botany,' vi, p. 100 (1892). The total number of ferns gathered by Sherring in Grenada was 145, most of the species being widely diffused through the West Indies. Three novelties included *Acrostichum Sherringii* Baker. Another fern was known before in Trinidad only, and two were continental types not hitherto found in the West Indies. When Mr. (now Sir) Daniel Morris paid a hurried visit to Grenada in January 1891 Sherring was able to show him in one district about 60 species of ferns in a single day.

In 'Kew Bulletin,' 1892, p. 188, there are comments on the orchids collected in Grenada; and Rolfe published the orchid *Brachionidium Sherringii* from Grenada in that journal (1893, p. 4).

Mr. Sherring resided at Bournemouth for over thirty years, up to 1925, when he returned to Hallatrow. He took an active part in the public life of Pokesdown and district, and as a keen Liberal was much interested in the education of the people. In association with others he was responsible for the erection of the Science and Art Technical School at Pokesdown, and was one of the new founders of the Bournemouth Natural Science Society, when restarted in 1903, and Secretary of the Botanical Section. He was the first recipient of the Society's Gold Medal, presented by Sir Daniel Morris in 1921, and in March 1928 was made an Honorary Member.

Sherring's interest in and systematic survey (with photographs) of the invasion of Poole Harbour by *Spartina Townsendii* is well known to present-day botanists because of his several reports and illustrated papers. At the British Association Meeting at Bournemouth in 1919 he took great delight in pointing out the progress of this grass to the botanists who one morning cruised around the harbour with him. He was a good photographer, and a cheerful and enthusiastic leader of parties exploring the Dorset heaths and commons.

In 1925 Sherring returned to Hallatrow with his unmarried daughter, who tended him in his increasing infirmity. At all times he took great interest in his garden, where many unusual plants were established.

Somewhat reserved and disinclined to commit himself until he got to know a person, Sherring had a kind and most generous heart : and his sense of fairness as between individuals was very marked. After his death the only remaining herbarium specimens (duplicates) were given to the British Museum. H. S. Thompson.

Herbert Sutcliffe died on the 26th November, 1930, at fifty years of age. He was trained at Bradford Technical School, and later at the Royal College of Science. In 1913 he proceeded to Malaya as mycologist to the Malay Peninsula Agricultural Association in Province Wellesley. In 1917 he was appointed mycologist and pathologist to the Rubber Growers' Association, Petaling. He acted as Senior Scientific Officer for some time at Petaling, and in 1926 joined the Rubber Research Institute of Malaya as pathologist and anatomist, a post which he held until his death. He was associated with Mr. Richards, Mr. Pincky, and myself in the production of several important papers dealing with the diseases of the rubber tree (*Hevea brasiliensis*), and in addition contributed original papers as follows: (1) A study of the defects in Crêpe and Sheet Rubber, (2) Internal fissures in the cortex of *Hevea*, (3) The use of Bitumens (Asphaltum mixtures) on Rubber Plantations. Nos. 2 and 3 were the most recent papers.

Sutcliffe was a most painstaking and thorough research officer whose work it was never necessary to repeat. In private life he was most unassuming and made a host of friends who held him in the highest regard. He was my colleague for thirteen years in the East, and a friend whom I held in the highest esteem, both for work and friendship.

He was elected a Fellow of the Linnean Society on the 5th May, 1921. A. R. Sanderson.

Ignatz Urban. Geheimer Regierungsrat Professor Dr. Ignatz Urban was one of our senior Foreign Members, having been elected in May 1901. His death, at Gross Lichterfelde, near Berlin, on January 7th last, his eighty-third birthday, followed shortly after that of his former chief, Adolf Engler. When Engler came from Breslau as Director of the Berlin Botanic Museum and Garden in 1889, Urban, who had been associated with the former Director, Wilhelm Eichler, since 1878, was appointed Unter-Direktor, a post he held until his retirement in 1913.

Born at Warburg, in Westphalia, in 1848, Urban was educated at the gymnasium of his native town and afterwards at that of Paderborn. Later he studied at the Universities of

Bonn and Berlin, taking up first philology, but subsequently natural science, especially botany, under Alexander Braun, Paul Ascherson, and L. Krug. The Franco-German War, in which he saw active service from 1870–1, interrupted his University Course, but in 1873 he took the degree of Ph.D. with a dissertation entitled "Ueber Keimung, Blüten- und Fruchtbildung bei der Gattung *Medicago*." In the same year he published a "Prodromus" of a monograph of the genus (Verh. Bot. Ver. Brandenb. xv), and in 1874 a "Conspectus" of its species, varieties, and forms known in cultivation. This early work is still authoritative for the genus.

From 1873–78 Urban held a teaching post at the Pædagogium at Lichterfelde. In 1878 Eichler succeeded Braun at Berlin and appointed Urban as First Assistant in the Botanic Garden, and later (1883) Custos. Eichler died in 1887, and until the appointment of Engler in 1889 the arrangements and negotiations for the transference of the Museum and Garden from their crowded quarters in Berlin to more spacious and open ground outside the city devolved on Urban. He had refused a call to the Professorship and the Directorship of the botanical garden at Göttingen in order to avoid a break in his work at Berlin. When the new site at Dahlem was decided on, and arrangements for transfer were begun in 1898, Urban took a large share in the removal and in organizing the new establishment. At the inaugural celebration at Dahlem in 1910, which followed the International Congress at Brussels, and was attended by botanists from all over the world, Urban received a well-merited recognition.

A chronological bibliography of Urban's work is included in the biographical notice by Prof. A. J. de Sampaio in the 'Boletim do Museu Nacional' (Rio de Janeiro), vol. iv, no. 1 (1928), where is also an excellent portrait. The list represents a continuous output of critical taxonomic work of the first class, with occasional contributions on the morphology of individual genera with which he had occasion to deal. But there was also a literary side to his mental equipment which found expression in a number of biographical notices and appreciations of the work of his botanical colleagues; we recall, for instance, those on George Engelmann and George Bentham in 1884, Sereno Watson, 1892, and his invaluable introduction to the 'Flora Brasiliensis' on the completion of that monumental work in 1906. The history and development of the Garden and Herbarium with which his official life was merged was also the subject of communications from time to time, including an exhaustive history of the Museum from 1815–1913 (the year of his retirement), with an enumeration of the collections contained in it.

Urban's most important and best known work, apart from his official duties, was the completion of Martius's 'Flora Brasiliensis' and his own 'Symbolæ Antillanæ.' Eichler was engaged on the continuation of the former ambitiously planned undertaking, and between 1877 and 1889 Urban contributed the account of several families. After Eichler's death he assumed the editorship and carried the work to a successful conclusion in 1906 in spite of serious difficulties, including the interruption of the subsidy from Brazil for its production. His own contributions after 1889 were confined to the invaluable Introduction, to which we have already referred. This restriction to the arduous editorial duties was due to his increasing interest in the West Indian floras. In 1884, with the help of the Berlin Academy of Sciences and a wealthy patron, Consul L. Krug, he inaugurated a botanical exploration of some of the islands. Large collections were made in Porto Rico by Sintenis, and in San Domingo and other islands by Eggers, Turckheim, and Fuertes. Later (1914–27) Dr. Ekman, with a subsidy from the Royal Academy of Stockholm, sent large collections from Cuba and Haiti. For some years the late William Fawcett transmitted an extensive representation of the Jamaica flora, and material was also sent by various collectors from other islands. Urban had, therefore, to his hand, in addition to that already stored in the great European herbaria, a great mass of new material which he elaborated from 1892–97 in Engler's 'Jahrbuch' under the title "Additamenta ad cognitionem Floræ Indiæ Occidentalis," fasc. 1–4, and later in the nine large volumes of his 'Symbolæ Antillanæ,' 1898–1925, and his "Serta Antillana," published in 28 fascicles in Fedde's 'Repertorium' between 1914 and 1927.

Apart from his two *opera magna*, Urban found time for other pieces of work, to some extent a continuation of subjects already treated in the 'Flora Brasiliensis,' such as a Monograph of Turneraceæ (1883) and, with E. Gilg, of Loasaceæ (1900). His account of Plumier's life and writings, with a key to his flowering plants (1920), was a valuable historical and scientific contribution to American botany. After his retirement in 1913 he was almost exclusively occupied with his work on the West Indian flora, which he continued up to the time of his death.

Urban was not a traveller. One did not meet him at Congresses or other functions abroad; the material for his work came to him in Berlin, and he rarely visited extra-continental herbaria. But he had an extensive correspondence, and his carefully worded post-cards seeking information on points of detail in minute closely written handwriting were characteristic of his intensive study of the subject

in hand. I recall a remark made many years ago by Dietrich Brandis at the Linnean Society: "What we need in botany is, not theories, but careful monographic work"; on these lines Urban has worked for close on sixty years.

Those who had the privilege of his acquaintance remember him as a man of unobtrusive but dignified bearing, courtly, kindly, and eminently helpful, with a strong personality behind a somewhat modest manner. He was happy in retaining health and faculties to a great age; his work and life ended with an enviable suddenness.

The high merit of his contributions to botany was recognised by honours at home and abroad. Besides honorary membership of many scientific societies he was a Chevalier of Prussian and Bavarian Orders and an Officer of the Rose of Brazil.

A. B. Rendle.

Bernard Barham Woodward (1853–1930). On Monday, 27th October, 1930, passed away Mr. B. B. Woodward, from an embolism following an internal operation. His death was quite unexpected, as he had in twelve days made considerable progress towards recovery.

Woodward was a member of a distinguished Norfolk family whose branches we give as follows:—Samuel Woodward, the geologist (1790–1838), left three sons—Bernard Bolingbroke (1816–69), Librarian to Queen Victoria at Windsor; Samuel Pickworth (1821–65), the conchologist; Henry (1832–1921), Keeper of Geology, British Museum. Of these, S. P. left Bernard Henry (1846–1916), of Perth, West Australia, Horace Bolingbroke, the well-known British geologist (1848–1914), and Herbert Willoughby (Missionary in S. Africa); Bernard Bolingbroke left Bernard Barham (1853–1930); and Henry left Harry Page (1858–1917) and Martin Fountaine (1865–1901), the W. Australian geologist and a rising zoologist respectively. This family had no connection with John Woodward of Staffordshire, and so far as we know that line seems to be represented by Sir A. S. Woodward, the palæontologist.

B B. Woodward, born at St. John's Wood, London, was at first in the Library of the Geological Society of London, and made a tabulated catalogue of the contents of their Museum. Afterwards he entered the service of the Trustees of the British Museum, and in 1881 was by them transferred to the new building at South Kensington and installed as Librarian. Rapidly evolving order out of chaos, he proved himself to be one of the greatest of the great librarians, and his catalogue of the books, etc., in the British Museum (Natural History) is a monument to his learning and industry, and has formed the standard in Academies and Universities all over

the world. It is rich in bibliographical details as well as in entries, and he drew largely on Sherborn's notes, the two friends working together for over forty years.

He had spent the leisure of many years on a professional study of the Mollusca and their literature, and was especially interested in the British Land and F. W. series. He was Chairman for many years to the Ealing Public Library, and took interest in other parish work.

Of his published works his great monument is his 'Catalogue of the Books, Manuscripts, Maps, and Drawings in the British Museum (Natural History),' in five volumes quarto, and 'Supplement A–I' (1903–1922), now in process of continuation.

He also wrote 'Catalogue of the British Species of Pisidium (recent and fossil), with notes on those of Western Europe,' octavo, London, 1913, and 'Synonymy of the British non-marine Mollusca (recent and post-Tertiary),' by Kennard and Woodward, octavo, London, 1926, both published by the Trustees of the British Museum.

A long series of shorter articles came from his pen, many in conjunction with Kennard and others.

Woodward had a great grasp of geology, microscopy, and zoology, and this stood him in good stead in his life's work.

He was a Member of the Geologist's Association from 1874, and acted as their Secretary for some five years; a Fellow of the Geological Society of London from 1880; of the Linnean Society from 1895; and of the Royal Microscopical Society from 1880.

He was twice married but left no issue. He was buried at Woking beside his wives. C. Davies Sherborn.

BENEFACTIONS.

LIST *in accordance with Bye-Laws, Chap.* XVII. *Sect.* 1, *of all Donations of the amount or value of Twenty pounds and upwards, received during the past Twenty years.*

1911.

The Trustees of the Percy Sladen Memorial Fund: Second Donation towards the publication of the third volume on the Indian Ocean Researches, £70.

The same: First Donation towards the fourth volume, £130.

1912.

The Indian Government: Contribution towards the illustration of Mr. E. P. Stebbing's paper on Himalayan *Chermes*, £46 15*s.* 2*d.*

The late Mr. Francis Tagart, £500 free of Legacy Duty.

The late Sir Joseph Dalton Hooker, O.M., G.C.S.I., £100 free of Legacy Duty.

The Trustees of the Percy Sladen Memorial Fund: Second Donation towards the publication of the fourth volume on the Indian Ocean Researches, £140.

The same: First Donation towards the fifth volume, £60.

1913.

Royal Society: Grant towards Dr. R. R. Gates's paper on Mutating Oenotheras, £60.

Sir Frank Crisp, Bt.: Wallichian Cabinets, £50.

The Trustees of the Percy Sladen Memorial Fund: Second Donation towards the publication of the fifth volume, £200.

1914.

Royal Society: Grant towards Miss Gibbs's paper on the Flora of British North Borneo, £50.

Miss Foot: Cost of illustration of her paper on *Euschistus*.

The Trustees of the Percy Sladen Memorial Fund: Third Donation towards the fifth volume, £10.

The same: First Donation towards the sixth volume, £190.

1915.

The Trustees of the Percy Sladen Memorial Fund: Second Donation towards the sixth volume, £80.

Miss Foot: Cost of second paper on *Euschistus*, £32 10*s*.

Royal Society: Donations towards the cost of a paper by Mrs. Arber, D.Sc., £40.

The same: towards paper on Utakwa River plants by Mr. H. N. Ridley, C.M.G., F.R.S., £50.

Miss Marietta Pallis: Instalment of cost of her paper on Plav, £30.

Thomas Henry Riches, Esq.: Dr. A. R. Wallace's library on Natural History.

Sir Frank Crisp, Bt.: New shelving for Wallace's Volumes.

1916.

Mr. E. Heron-Allen: Contribution to cost of paper on Foraminifera of N.W. Scotland, £44.

Messrs. H. Takeda and C. West: Contribution towards the illustration of their paper, £40.

Royal Society: Contribution towards the illustration of two papers by Prof. Dendy, £40.

The same: Contribution towards Mr. Swynnerton's paper on Form and Colouring, £70.

The High Commissioner for the Union of South Africa, per Dr. J. D. F. Gilchrist, for the illustration of his paper on *Jasus Lalandii*, £30.

Miss Marietta Pallis: Balance of cost of her paper on Plav, £90 16*s*. 6*d*.

Sir Frank Crisp, Bt.: Phototyped copy of Dioscorides from the 'Codex Aniciæ Julianæ' at Vienna.

1917.

British Ornithologists' Union, etc.: Contribution towards cost of Mr. H. N. Ridley's paper, £20.

The Royal Society: Second contribution towards the printing of Mr. C. F. M. Swynnerton's paper on Form and Colouring, £75.

Sir Frank Crisp, Bt.: 'Lindenia,' Ghent, 1891–1901. 17 vols. sm. fol.

1919.

Dr. B. Daydon Jackson: MS. index to Linnean Society's Journal, Botany, vols. xxi.–xl. (1884–1912) and the Botanic entries in the 'Proceedings' for the same period.

1920.

The Royal Society: Third contribution towards the printing of Mr. C. F. M. Swynnerton's paper as above, £50.

The High Commissioner for the Union of South Africa, for the printing of Dr. J. D. F. Gilchrist's paper on *Jasus Lalandii*, Part II., £60.

1921.

The Percy Sladen Memorial Fund: Additional Grant in aid of publication of 'Transactions,' 2nd ser., Zoology, vol. xvii. part 4, £72 10*s*.

The same: Grant in aid of publication of four papers on the Houtman Abrolhos Islands, £100.

The Royal Society: Donation in aid of papers by Mr. N. E. Brown and Mr. S. L. Moore, £90.

Dr. W. Rushton Parker: Donation of a large series of portraits of Naturalists and Persons after whom Genera have been named, and work on rearrangement and annotation of the entire collection.

Prof. C. S. Sargent, F.M.L.S.: Eight volumes issued by the Arnold Arboretum including "The Bradley Bibliography."

Dr. B. Daydon Jackson: MS. Catalogue of each sheet in the Linnean Herbarium; bound in two volumes folio.

1922.

The late Sir Joseph Hooker: Donation of his Medals and Decorations. (Reversion to Linnean Society on Lady Hooker's decease.)

Anonymous donation in aid of publication of the late Dr. E.A. Newell Arber's paper, entitled "Critical Studies of Coal-Measure Plant-impressions," £60.

The Percy Sladen Memorial Fund: Cost of printing and illustrating 'Transactions,' 2nd. ser., Zoology, vol. xviii. pt. i.

1923.

Dr. W. Rushton Parker: (1) Donation of Oxford New English Dictionary; vols. i.–ix., vol. x. in parts, 4to, 1888–1923→ (2) Encyclopædia Britannica; ed. XI. Cambridge, 1920–22. 32 vols. 4to.

E. Heron-Allen, Esq., F.R.S.: Contribution of £25 towards the cost of paper on the Foraminifera of Lord Howe Island.

1924.

The Percy Sladen Memorial Fund: Cost of printing and illustrating 'Transactions,' 2nd. ser., Zoology, vol. xviii. pt. ii.

1925.

An Anonymous Donor: New Presidential Chair, emblazoned with the Arms of the Society.

1926.

Subscription portrait of Dr. B. D. Jackson, R.N.O.

Mr. A. D. Michael: A large number of Books and Pamphlets from his Library.

The late Mr. A. O. Walker: £200 free of Legacy Duty.

An Anonymous Donor: £100 to establish a Fellowship in memory of the late Prof. E. A. Minchin, F.R.S., Sec.L.S.

The Royal Society: Donation in aid of publication of Mr. G. P. Farran's paper on Biscayan Plankton.—Part 14. The Copepoda, £60.

The late Mr. Frank Morey: £100 free of Legacy Duty.

The late Mr. George Lewis: Books and pamphlets on Entomological subjects.

Capt. E. G. Spencer-Churchill: A copy of a collotype reproduction of 'The herbal of Apuleius Barbarus . . . (MS. Bodley 130).'

The Percy Sladen Memorial Fund: Cost of printing and illustrating 'Transactions,' 2nd ser., Zoology, vol. xix. pt. i.

1927.

The late Mrs. Mary Anne Stebbing: £100 less Legacy Duty.

1928.

Carnegie United Kingdom Trust: £666 13*s.* 4*d.* for purchase of books.

The Royal Society: £160 (£85 in aid of the publication of Dr. G. Enderlein's paper on "Die Copeognathen der Seychellen," £75 in aid of Mr. C. V. B. Marquand's paper on "The Botanical Collections made by Capt. F. Kingdon Ward in the Eastern Himalaya and Tibet in 1924–25").

1929.

Carnegie United Kingdom Trust: £666 13*s.* 4*d.* for purchase of books.

The Percy Sladen Memorial Fund: £100 in aid of the publication of papers on the Fauna of the Paraguayan Chaco.

Carnegie Trust for the Universities of Scotland: £28 in aid of the publication of papers on the Fauna of the Paraguayan Chaco.

1930.

Carnegie United Kingdom Trust: £666 13*s.* 4*d.* for purchase of books.

An Anonymous Donor: £23 towards the purchase of an Epidiascope.

The Royal Society: £100 in aid of the publication of Mr. H. W. Pugsley's paper "A revision of the British Euphrasiæ" and Dr. T. A. Sprague's paper "The Herbal of Leonhart Fuchs."

Mrs. B. Daydon Jackson (the late): valuable reversion under her Will after three life-tenants shall have died.

Mr. B. B. Woodward (the late) and Mr. A. S. Kennard: a portion of Mr. Woodward's scientific library and reversion of the remainder.

1931.

Miss E. C. Hatchett Jackson: Bust of Charles Hatchett, F.L.S., by Chantrey.

Major Vivian Seymer: Volumes from the Library of Henry Seymer.

Treasurer's Accounts for the

(Presented at the Anniversary

Receipts and Payments of the Linnean Society

General

Receipts.	£	s.	d.	£	s.	d.
To Balance at 1st May, 1930	675	8	0			
Do. deposits, Fellows' postal account	70	6	0			
,, Cash in hand	16	3	8			
				761	17	8
,, Admission Fees				60	0	0
,, Arrears of Annual Contributions	30	0	0			
,, Annual Contributions for year	2468	0	0			
Do. in advance	84	0	0			
				2582	0	0
,, Interest on Investments (including Income Tax recovered)				323	6	3
Do. Deposit				12	4	1
,, Sales of Publications:—						
Transactions	57	8	2			
Journals	261	5	1			
Proceedings	9	2	3			
Library Catalogue	3	1	0			
				330	16	6
,, Donations in aid of Publications				100	0	0
,, Donations for General Purposes				24	0	0
,, Fellows' postal account, deposits				11	2	3
,, Miscellaneous Receipts				27	6	0
				£4232	12	9

Library

Receipts.	£	s.	d.
To Balance 1st May, 1930	44	19	2
,, Interest on Investments (including Income Tax recovered)	49	17	2
,, Carnegie United Kingdom Trust—second half of last Third of £2000 Grant	333	6	8
,, Transferred from General Account	266	13	4
	£694	16	4

YEAR ENDED APRIL 30TH, 1931.

Meeting, May 28th, 1931.)

from May 1st, 1930, to April 30th, 1931.

Account.

PAYMENTS.	£	s.	d.	£	s.	d.
By Coal, Electric Current, and Gas				101	10	7
,, Furniture				176	0	11
,, Repairs, sundry				225	12	8
,, Taxes and Insurance				42	6	4
,, Miscellaneous Printing and Stationery				220	3	7
,, Petty Expenses (including Tea and Postage)				157	14	8
,, Publications :—						
Printing	917	0	0			
Illustrations	88	3	2			
Distribution	72	4	0			
				1077	7	2
,, Salaries and Wages, etc.				1020	10	8
,, Transferred to Library Account				266	13	4
,, ,, ,, Goodenough Fund				5	0	0
,, Zoological Record: Donation for 1930 volume				15	0	0
,, Freshwater Biological Association Endowment Fund: Donation				5	5	0
,, Hooker Memorial Tablet: Donation				5	0	0
,, Purchase of £186 9*s.* 7*d.* 3½ per cent. Conversion Stock (Staff Pension Fund)				150	0	0
,, Purchase of Publications for Stock				10	0	0
,, Linnean Medal				15	0	0
,, Fellows' postal account				22	11	11
,, Balance at 30th April, 1931	645	8	7			
Do. Fellows' postal account deposits	58	16	4			
,, Cash in hand	12	11	0			
				716	15	11
				£4232	12	9

Account.

PAYMENTS.	£	s.	d.
By Books	140	18	10
,, Periodicals	272	12	6
,, Binding	199	10	7
Balance of 30th April, 1931	81	14	5
	£694	16	4

Separate Account.

			£	s.	d.
To Balance at 1st May, 1930:—					
Westwood Fund	£52	14 10			
Trail Award Fund	17	4 2			
Crisp Award Fund	24	4 7			
Hooker Lecture Fund	67	1 9			
Goodenough Fund	21	4 4			
Linnean History Fund	21	9 6			
Minchin Fellowship Fund	1	10 0			
			205	9	2
„ Goodenough Fund:—					
Transferred from General Account			5	0	0
„ Interest on Investments (including Income Tax recovered):—					
Westwood Fund	£9	12 4			
Trail Award Fund	3	10 0			
Crisp Award Fund	7	10 0			
Hooker Lecture Fund	22	8 5			
Goodenough Fund	8	3 2			
Minchin Fellowship Fund	4	17 6			
Staff Pension Fund	6	19 3			
			63	0	8
			£273	9	10

			£	s.	d.
By Trail Award to Miss K. B. Blackburn			16	12	6
„ Goodenough Fund:—					
Transferred to Annual Contributions			12	0	0
„ Minchin Fellowship Fund:—					
Transferred to Annual Contributions			4	0	0
„ Staff Pension Fund:—					
Purchase of £8 15*s.* 6*d.* 3½ per cent. Conversion Stock			6	19	3
„ Balance at 30th April, 1931:					
Westwood Fund	£62	7 2			
Trail Award Fund	4	1 8			
Crisp Award Fund	31	14 7			
Hooker Lecture Fund	89	10 2			
Goodenough Fund	22	7 6			
Linnean History Fund	21	9 6			
Minchin Fellowship Fund	2	7 6			
			233	18	1
			£273	9	10

Investments on April 30th, 1931.

General Account.

£	s.	d.			*Market Value, 30th April, 1931.* £	s.	d.
1000	0	0	Metropolitan 3 per cent. Stock 1941	@ 91	910	0	0
1200	0	0	India 3 per cent. Stock	@ 50½	606	0	0
1000	0	0	Eastern Bengal Railway 4 per cent. Irredeemable Debenture Stock	@ 65	650	0	0
1000	0	0	Great Western Railway 4 per cent. Debenture Stock	@ 83½	835	0	0
312	0	0	London Midland & Scottish Railway 4 per cent. Preference Stock	@ 49	152	17	7
3296	0	0	4½ per cent. Conversion Stock 1940–44	@102½	3378	8	0
					£6532	5	7

Library Account.

£	s.	d.			£	s.	d.
450	0	0	Forth Bridge Railway 4 per cent. Stock (Bentham Bequest)	@ 80½	362	5	0
200	0	0	4½ per cent. Conversion Stock 1940-44 (Walker and Morey Bequests)	@102½	205	0	0
530	0	0	East Indian Railway 3½ per cent. Debenture Stock (Tagart Bequest)	@ 57	302	2	0
88	9	8	London County 5 per cent. Stock 1940–60 (Stebbing Bequest)	@104	92	0	5
					£961	7	5

Separate Account.

£	s.	d.				£	s.	d.
£1012 9 5	232	5	0	Metropolitan Water Board 3 per cent. "B" Stock (Westwood Fund)	@ 68	157	18	7
	638	4	5	Ditto ditto (Hooker Lecture Fund)	@ 68	433	19	10
	142	0	0	Ditto ditto (Goodenough Fund)	@ 68	96	11	2
	100	0	0	New South Wales 3½ per cent. Stock, 1930-50 (Trail Award Fund)	@ 45	45	0	0
	300	0	0	2½ per cent. Consolidated Stock (Crisp Award Fund)	@ 58½	175	10	0
£200 0 0	50	0	0	4 per cent. Victory Bonds (Westwood Fund)	@ 96½	48	5	0
	50	0	0	Ditto ditto (Hooker Lecture Fund)	@ 96½	48	5	0
	100	0	0	Ditto ditto (Goodenough Fund)	@ 96½	96	10	0
	100	0	0	London County 5 per cent. Stock 1940–60 (Minchin Fellowship Fund)	@104	104	0	0
	445	5	11	3½ per cent. Conversion Stock (Staff Pension Fund)	@ 81½	362	18	4
				(£4 7*s.* 11*d.* Ditto, to be transferred on 1st May, 1931.)		£1568	17	11

FRANCIS DRUCE, *Acting Treasurer.*

We have (in conjunction with the Professional Auditor, who certifies as to all details) audited the Accounts of the Society for the year ended 30th April, 1931, and found them correct. We have verified the Investments and Bank Balances.

Dated this 12th May, 1931.

W. B. KEEN, *Chartered Accountant.*

E. J. BUTLER,
PHILIPPA C. ESDAILE,
ROBERT PAULSON,
R. H. BURNE } *Auditors.*

ADDITIONS AND DONATIONS

TO THE

LIBRARY.

1930–1931.

Note.—Separate copies of papers which are included in periodicals received by the Library are no longer catalogued. Names of donors are given in square brackets. The sizes are given in centimetres,—to the nearest centimetre.

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Bannerman, D. A. The Birds of Tropical West Africa. Vol. 1→ *London*, 1930→ 26×18 [Crown Agents for the Colonies.]

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